ANNALS

of the Association of American Geographers

LIBRARY
MAR 29 '60
DARTMOUTH COLLEGE

WALTER M. KOLLMORGEN
Editor

Volume 50 • Number 1

March 1960

CONTENTS

Count Buffon on Cultural Changes of the Physical Environment — Clarence J. Glacken 1

Estimates of Water Uses in the Muskingum Watershed Conservancy District for 1975 — Morgan D. Thomas 22

The Conflict Between Fish and Power Resources in the Pacific Northwest — M. E. Marts and W. R. D. Sewell 42

Wellington Downing Jones, 1886–1957 — Charles C. Colby 51

Letters and Comments on Annals Topics

Rigidity of Rail Hinterland Boundaries in Australia — Robert H. T. Smith 55

One Chinese View of the "Hydraulic Society" — Theodore Herman 57

Projection Pitfalls — Waldo R. Tobler 58

The Spacing of River Towns — Michael F. Dacey 59

Review Articles

Comparative Studies in Frontier History — Marvin W. Mikesell 62

Vegetation Mapping in Africa — A. W. Küchler 74

Map Supplement

Cyprus—A Landform Study — Norman J. W. Thrower

ANNALS of the Association of American Geographers is published quarterly in March, June, September, and December at the Allen Press, Lawrence, Kansas

Subscription rate: $10.00 per calendar year
Volumes 48 and later: $10.00 per volume; $2.50 per issue
Volumes 42–47 incl.: $5.00 per volume; $1.25 per issue
Volume 41: $4.00 per volume; $1.00 per issue

Address all communications relative to subscriptions, purchase of back numbers, etc., to Association of American Geographers, 1785 Massachusetts Ave., N.W., Washington 6, D.C.

Submit all manuscripts to
Walter M. Kollmorgen, *Editor*, Dept. of Geography, University of Kansas, Lawrence, Kansas

Submit publications for review and also reviews to
Marion E. Marts, *Review Editor*
Dept. of Geography, University of Washington, Seattle 5

Submit maps for map supplement to
Richard Edes Harrison, *Map Editor*
313 E. 51st Street, New York City 22, N.Y.

Statements and opinions in the ANNALS *are the responsibility of authors and do not necessarily reflect the views of the Association*

Entered as second class matter at the Post Office at Lawrence, Kansas. Acceptance for mailing at special rate of postage provided for in Section 1103, Act of Congress of October 3, 1917, authorized March 28, 1923.

ANNALS of the
Association of American Geographers

Volume 50 March 1960 Number 1

COUNT BUFFON ON CULTURAL CHANGES OF THE PHYSICAL ENVIRONMENT

CLARENCE J. GLACKEN
University of California, Berkeley

THE *Histoire Naturelle, Générale et Particulière* of Georges-Louis Leclerc, later Comte de Buffon (1707–88), is one of the enduring masterpieces of the eighteenth century.[1] The forty-four volume edition in quarto

[1] The problem of citation to the works of Buffon is a difficult one because of the many editions of his works. Citations here are to *Histoire Naturelle, Générale et Particulière* (Paris, 1749–1804), 44 volumes. All of the earlier and many of the modern writers refer to this edition. Its great advantage is that it gives precise datings for changes in thought and corrections of errors. It is divided into seven series: (1) *Histoire Naturelle, Générale et Particulière, avec la Description du Cabinet du Roy* (by Buffon and Daubenton). This series of 15 volumes (1749–67) includes the history and theory of the earth, proofs of the theory of the earth, natural history of man, the quadrupeds, and the wild animals. (2) *Histoire Naturelle des Oiseaux*, 9 volumes (1770–83). (3) *Supplément à l'Histoire Naturelle*, 7 volumes (1774–89). *Des Époques de la Nature* was first published in Vol. 5 (1778) of this series. (4) *Histoire Naturelle des Minéraux (et Traité de l'Aimant)*, 5 volumes (1783–88). The last three series were written by La Cépède: (5) *Histoire des Quadrupèdes Ovipares et des Serpents*, 2 volumes (1788–89); (6) *Histoire Naturelle des Poissons*, 5 volumes (1798–1803); (7) *Histoire Naturelle des Cétacés*, 1 volume (1804). For a detailed analysis of the contents of each of the volumes of this edition, see *Oeuvres Philosophiques de Buffon*, cited below, pp. 522–524.

After the citation in the following footnotes, there is in parentheses a general reference to the specific article which will be helpful in locating the passage in other editions. The most famous of the modern editions of Buffon are the *Oeuvres Complètes de Buffon* (Paris, 1853–55) edited by Pierre-Marie-Jean Flourens, and an edition of the same title by J. L. Lanessan (Paris, 1884–85). Modern editions of Buffon's works combine the articles in the supplementary volumes of the first edition with the original articles in the first 15 volumes of the *Histoire Naturelle* to which they refer.

Two important works have appeared on Buffon in recent years. (1) *Oeuvres Philosophiques de Buffon. Texte Établi et Présenté par Jean Piveteau. Avec la Collaboration de Maurice Fréchet & Charles Bruneau. (Corpus Général des Philosophes Français. Auteurs Modernes*, Vol. 41, 1), (Paris, 1954). This impressive work contains selections from the writings of Buffon organized around the main scholarly activities of his life; an illuminating introduction by Jean Piveteau on Buffon's thought in relation to his contemporaries and to the Western philosophical and scientific tradition; and an exemplary bibliography (pp. 513–575) prepared by E. Genet-Varcin and Jacques Roger of which items 1–354 are concerned with Buffon's writings, and 355–1152 with the literature on Buffon. This work is the necessary starting point for studies of Buffon. (2) *Buffon*, by Léon Bertin, Franck Bourdier, Ed. Dechambre, Yves François, E. Genet-Varcin, Georges Heilbrun, Roger Heim, Jean Pelseneer, Jean Piveteau (Paris, 1952). This symposium is a fundamental modern study of Buffon dealing, among other topics, with his life and work, his work as *intendant* of the Jardin du Roi, his religious thought, his ideas of generation, his article on the dog. In addition there are interesting chapters on the portraits made of Buffon, some of his unedited letters, and a valuable bibliographic essay. Two older works of great value in understanding Buffon's ideas of natural history and their relation to contemporary science are: Pierre-Marie-Jean Flourens, *Histoire des Travaux et des Idées de Buffon* (2me édition; Revue et augmentée, Paris, 1850), and Daniel Mornet, *Les Sciences de la Nature en France, au XVIII^e Siècle* (Paris, 1911). See also Louis Roule, *Buffon et la Description de la Nature* (Paris, 1924).

There is no translation of Buffon's complete works into English. The closest approach is William Smellie's *Natural History, General and Particular* (New edition, with various additions by William Wood; London, 1812), 20 vols. Smellie's translation (vols. 1–10) includes the first 15 volumes of the *Histoire Naturelle* (but excludes Daubenton's anatomical descriptions) and materials from a supplementary volume on the history of the quadrupeds; or, in brief, the history and theory of the earth, the history of man and the quadrupeds. The Smellie translation has been reprinted several times. A translation of the history of birds (Vols. 11–20) completes this set. Neither is there a complete translation of *Des Époques de la Nature*. Smellie considered it "exceedingly ingenious" but "perhaps too fanciful to receive

was published by the Royal Printing Office between 1749 and 1804, the last eight volumes being from the pen of La Cépède who continued Buffon's work after his death.[2]

The *Histoire Naturelle* is the outstanding example of the great eighteenth century effort, made especially in France, to unfold "le grand spectacle de la nature," to discover its laws, the nature of the earth with its living marvels and the organic harmonies upon it, and to seek an explanation of the distribution of plants, animals, and of man. One consequence of this very ambitious plan, which Buffon did not live to complete, was that his thought ranged widely over such fields as astronomy, geology, geography, biology, population theory, and "moral arithmetic," ethnology, forestry, and mineralogy; his work is thus a repository of many ideas concerning the earth, plants, animals, and man which were discussed and debated not only in the eighteenth century but in the seventeenth as well.

This essay, however, is concerned with only one aspect of Buffon's thought: his repeatedly expressed interest—often cursory and not fully explored—in the changes which men had made in their natural environment, particularly the transformations which had accompanied the growth and expansion of civilization and the migration and dispersion of human beings and their domesticated plants and animals throughout the habitable parts of the earth (Fig. 1). The nature of these changes is a recurring theme in many unexpected places of the *Histoire Naturelle* and is the subject matter of the seventh and last epoch in *Des Époques de la Nature*. The environmental changes through human agency described by Buffon were those which were familiar and traditional in the history of Western civilization; the new interpretations based on the use

FIG. 1. Man, noble in figure and in carriage, knows how to use the riches of nature for his own purposes. From *Le Buffon de la Jeunesse* (4th ed.; Paris, 1809), Vol. 1, frontispiece.

of coal and steam and the accelerating use of minerals came long after his time.

Buffon considered this question of the physical changes in the earth brought about by human agency in more detail than had any of his contemporaries, indeed more than any man in Western science or philosophy had considered it until George P. Marsh's *Man and Nature* was published in 1864. To my knowledge there has been no study showing the range of Buffon's ideas on this subject. Lucien

the general approbation of the cool and deliberate Briton." He did translate some of the main arguments of the first six epochs ("Facts and Arguments in support of the Count de Buffon's Epochs of Nature") and the seventh epoch in its entirety ("Concerning that Period when the Powers of Man aided those of Nature").

[2] The following abbreviations have been used:

AD	*Les Animaux Domestiques*
AS	*Les Animaux Sauvages*
Bertin	*Buffon*, by Léon Bertin, *et al.*
DA	*De la Dégénération des Animaux*
EN	*Des Époques de la Nature*
HN	*Histoire Naturelle, Générale et Particulière.* Refers to the 15 volumes published 1749–1767.
HNH	*Histoire Naturelle de l'Homme*
HNM	*Histoire Naturelle des Minéraux*
HNO	*Histoire Naturelle des Oiseaux*
HNS	*Suppléments à l'Histoire Naturelle*, etc. Refers to the 7 volumes published 1774–1789.
OP	*Oeuvres Philosophiques de Buffon*, ed. by Jean Piveteau
TE	*Histoire et Théorie de la Terre*
TV	*De la Terre Végétale*

Febvre saw them shining brightly in the dark night of environmentalism, but his discussion of them is too brief to reveal the manner in which Buffon anticipated the ideas of possibilism and had himself made use of environmentalistic ideas.[3] Buffon's interest in the physical changes in the earth peculiarly associated with the activities of man were philosophical, scientific, and practical. These changes, he thought, had been necessary to create civilization and to permit its growth and diffusion. "Wild nature is hideous and dying; it is I, I alone, who can make it agreeable and living." Dry out the marshes, he said, make their stagnant waters flow in brooks and canals, clear out the thickets and the old forests with fire and iron. In their place make pastures and arable fields for the ox to plow so that a "new nature can come forth from our hands."[4] These changes were also necessary because of his theories of the gradual cooling of the earth and the inadequacy of solar heat. Man must aid nature by changing it so that more of the sun's heat could warm the earth's surface. It was not the first time that erroneous theories led to new ways of looking at human history.

The dominant interpretation in Buffon's time of the nature of human modifications of the natural order was of Stoic–Christian origin. Man lives in a designed world made for all life by the Creator. Appointed by God as a steward over the earth, he has a role, comparable although far less glorious and far less powerful, to God's direction of the universe. As master of the earth, man's duty is to improve it and to perfect it; that had been the Creator's intention.[5] Buffon's ideas depart somewhat from this traditional interpretation; they resemble instead the anti-teleological ideas of Lucretius. Buffon rejected the doctrine of final causes,[6] although observations of a marked teleological bias occasionally appear in his work.

EIGHTEENTH CENTURY INTERESTS IN THE STUDY OF NATURE AND MAN

The thinkers of the eighteenth century, Buffon among them, were continuing to ask the great unsolved questions which had been bequeathed to them from the past, some from classical antiquity and the Middle Ages, others from the unprecedented situation created by the discovery of the New World.

First, there was the continuing problem of the nature of the earth, the manner of its formation, the history of the transformations it had undergone, either through the operation of natural laws or through divine interventions. Buffon's painstaking examination in his *Histoire et Théorie de la Terre*[7] of the systems of Whiston, Burnet, and Woodward and the exposition of his own theory, compromised at times to placate the theologists by reconciling earth history with Genesis, reveals both the intense interest in the subject and the poverty of the results in an age when speculation was far ahead of theoretical knowledge and technical invention. These themes involved related questions of the habitability of the earth, variations in its relief, the ratio of sea to land, and changes in climate at various times and places. They brought into prominence, therefore, problems which were basically historical ones.

In the second place, there was the problem of the nature of life and the manner in which it should be studied. How in their infinite variety could living things be grouped and organized for study? Buffon adopted an ancient idea which had been revived, refined, and popularized by Leibnitz, whom Buffon greatly admired. Life is arranged in a chain of being ("scale" and "ladder" were also commonly used expressions) from the simplest organisms to the most complex. There are so many forms of life that the gradation between

[3] Lucien Febvre in collaboration with Lionel Betaillon, *A Geographical Introduction to History*, trans. from the French by E. G. Mountford and J. W. Paxton (London and New York, 1925), pp. 7–8.

[4] *HN*, Vol. 12, p. xiii ("De la Nature. Première Vue").

[5] See my "Changing Ideas of the Habitable World," in William L. Thomas, Jr., ed., *Man's Role in Changing the Face of the Earth* (Chicago, 1956), pp. 70–92, for a short history of the idea of man as a modifier of the physical environment.

[6] On Buffon and final causes, see Piveteau, *OP*, pp. xxxv–xxxvi. Buffon said that Nature's ends are more general than our views. See also *HN*, Vol. 5, pp. 102–103 ("Le Cochon, le Cochon de Siam et le Sanglier"). On Buffon's difficulties with the theologians, see Piveteau, "La Pensée Religieuse de Buffon," in Bertin, pp. 125–132; on Buffon's reconciliation of his own ideas with the account of the creation in Genesis, see *HNS*, Vol. 5, pp. 28–39 (*EN*, intro.).

[7] *HN*, Vol. 1, pp. 168–188.

one form and the other is scarcely perceptible.[8] Buffon's belief in the chain of being accounts, at least in part, for his celebrated attack on Linnaeus. Systems of classification, he thought, existed in men's minds; they had no reality in nature. (Buffon's attack damaged his own reputation because of the worship, sometimes approaching idolatry, of Linnaeus.[9] Buffon's critics accused him of being a superficial student whose writings were of more interest to ladies of the salon than of value to science. Later in life Buffon was more tolerant of taxonomy.) Whether life was regarded as a chain of being whose gradations were so fine that any system of classification would be arbitrary, or whether taxonomy was an indispensable preliminary to further study and understanding of nature, the position of man in either scheme had to be considered because man was both an animal and a being set apart from all other kinds of life. This theme of man's place in nature exists in many different forms in the eighteenth century; it has an important place in the philosophy of Buffon.

These interests and controversies naturally encouraged and were encouraged by scientific travel. The problems presented by the comparative study of the flora and fauna of the Old and New World and the continuing study of the natural history of Europe also increased the desire for a more profound knowledge of natural history and for more intensive scientific collecting. Buffon's *Histoire Naturelle* and the policies of the Jardin du Roi, before and after he became *intendant*, are excellent examples of this passion for collection, comparison, description, and if one had the talent, for the exposition of exalted general views.

In the third place, there was the question of the nature and growth of civilization. Many of the most famous thinkers of the century, like Condorcet, Montesquieu, Voltaire, Rousseau, Turgot and Herder, had written on such themes as the progress of mankind, the significance of cultural inertia, and environmental influences which caused some peoples to progress and others to lag behind. These studies included theories of the origin of human society and of the arts and sciences. They involved also speculation regarding physical environments hospitable to early civilization. Were they harsh, unhealthful, and forbidding compared with the comfortable landscapes of civilized life? On this question Buffon took an unequivocal stand. He had little patience with romanticizing about the state of nature or of primitive society.

Theories of origins were related to the question of the unity of the human race and the manner of its dispersion throughout the world. The thinkers of the eighteenth century did not initiate these studies, but they contributed much to them, with their theories of population growth and of possible migration routes. Accepting the original unity of the human race called for explanations of the later cultural and physical diversity of mankind. A considerable body of eighteenth century thought was preoccupied with this old problem. Since classical times, climate had been a popular explanation but in the eighteenth century alternatives were offered, notably by Hume,[10] which stressed cultural differences. Moreover, the puzzling distribution of mankind over the earth, which had become known at least in its broad outlines, called attention to the question of population density, and to the contrasts in the distribution of population in Europe, parts of Asia, especially China and India, and in the New World.

During the latter part of the seventeenth century and all of the eighteenth, men were studying the voyages and travels much more systematically and intensively than before. They had a sense of the uniqueness of landscapes created by civilizations. Many travelers had mentioned the contrasts between the environments inhabited by civilized peoples

[8] On the history of this idea, see Arthur Lovejoy, *The Great Chain of Being* (Cambridge, Mass., 1948 [1936]). See also Philip P. Wiener, ed., *Leibniz. Selections* (New York, 1951), pp. 454–455 ("New Essays on the Human Understanding" [1704], Book III, Chap. vi, §12); Buffon, *HN*, Vol. 5, *loc. cit.*

[9] For an interesting modern critique of Buffon and Linnaeus, see Charles E. Raven, *Natural Religion and Christian Theology. The Gifford Lectures 1951. First Series: Science and Religion* (Cambridge, 1953), pp. 145–163. See also Raven's striking tribute to Buffon's *Histoire Naturelle* despite his criticisms of the work. Raven calls it "the most important attempt yet made to collect, describe and assay all the available knowledge of nature" (p. 149).

[10] David Hume, *Essays Moral, Political, and Literary*, ed. by T. H. Green and T. H. Grose (London, 1898), Vol. 1, pp. 244–258 ("Of National Characters").

(the Europeans and the Chinese were favorite examples) and those inhabited by primitive peoples. Even Montesquieu, so well known for his theories of climatic influence, described the nature of landscapes created by civilization and the types of land use associated with kinds of economic activity.[11]

Many thinkers of the eighteenth century were interested also in the relation of technology and applied science to the progress of civilization. Inventions and applications of scientific theory—new agricultural tools, improved drainage techniques, new ideas in planting trees or in laying out gardens—had brought about distinct changes in the landscape. With few exceptions, it was assumed that applications and techniques of this kind improved the appearance of the landscape. It would give it order and beauty; complaints that industrialization would create disorder and ugly landscapes were not heard in volume until the nineteenth century.

The interest in so many themes, each with a different history, led to confusions; ideas concerning the relationship of man to the environment were badly in need of reconciliation. Eighteenth century thinkers appreciated the cosmopolitanism and the pioneering spirit of the human race. The descriptions in the voyages and travels had left little doubt that men could exist under all kinds of environmental conditions. Entirely different in spirit, however, were the ideas of climatic influence so spectacularly revived by Montesquieu.[12] They were used far more freely and broadly than they were in classical times, the Middle Ages, and the Renaissance to explain cultural, racial, and even individual human differences. Mankind in these climatic molds was far indeed from a heroic cosmopolitanism. Complicating matters further were the brief but frequent statements of European travelers and settlers in the colonies claiming changes in climate due to clearing, drainage, or agriculture. These accounts, often unconsciously, depicted the settlers as active and determined men in their zeal to transform, against great odds, the lands on which they had recently settled.

The *Histoire Naturelle* itself is an excellent source of all these trends because of its length, its documentation, its errors and corrections and because it is not the work of Buffon alone. It is also the work of predecessors and of his collaborators who gathered much of the information (Buffon was impatient with detail, partial to elegant general views, and his eyesight was too poor for prolonged reading) and the scientists and scholars of the Jardin du Roi. The *Histoire Naturelle* is a mirror of the scientific activity of this institution. Buffon was its *intendant* from 1739 to 1788, and its resources, its correspondents, its collections were indispensable to Buffon who in turn provided the leadership needed for the growth of a great institution. "If the Museum owes its splendour to Buffon, to this magnificent establishment Buffon owes his fame."[13] The histories of the Jardin du Roi communicate a feeling of the excitement and fervor of its scientists in studying natural history and in adding to its collections.[14] An engraving entitled "Study unveils the secrets of nature," the frontispiece of a book on natural history for the young, expresses this sentiment very well.[15]

The *Histoire Naturelle* satisfied a hunger for concrete and detailed knowledge that was not dependent on mathematics or Cartesian deductive reasoning, but on study, travel, observation, and description. Paul Hazard has remarked that in the eighteenth century mathematics and particularly geometry lost their supremacy because men felt that deductive processes of thinking added nothing to the stock of human knowledge.[16] The study of natural history did.

[11] *The Spirit of Laws*, trans. by Thomas Nugent (New York, 1899), Book XVIII, chap. 7, 10.

[12] *Ibid.*, Books XIV–XVII.

[13] Joseph-Philippe-François Deleuze, *History and Description of the Royal Museum of Natural History*, Eng. trans. (Paris, 1823), Vol. 1, p. 27.

[14] Paul Antoine Cap, *Le Muséum d'Histoire Naturelle* (Paris, 1844). This extremely interesting work is very well illustrated. On Buffon's term as *intendant* see pp. 23–98; see also Deleuze, *op. cit.*, pp. 26–61.

[15] Anon., *Histoire Naturelle Mise à la Portée de la Jeunesse d'après Buffon et les Plus Célèbres Naturalistes* . . . (3rd ed.; Paris, 1803), Vol. 1, frontispiece. The many editions of selections from Buffon would make an interesting study in the popularization of natural history: for example, *Buffon des Écoles*, *Buffon des Familles*, *Buffon des Demoiselles*, and *Buffon du Premier Âge*. See *OP*, pp. 527–528. In England, Oliver Goldsmith did much to popularize Buffon in his *An History of Earth, and Animated Nature* (London, 1774), 8 volumes.

[16] Paul Hazard, *European Thought in the Eighteenth Century from Montesquieu to Lessing*, trans. by J. Lewis May (New Haven, 1954), p. 130.

NATURE AND MAN

Buffon wrote that nature is a system of laws established by the Creator to govern the existence of things and the succession of beings. In his exposition, revealing clearly the influence of Newton, Buffon said that the system of laws applies to the whole universe. Nature itself is not an entity; if it were, it would encompass everything. Neither is it a being, for then it would be God. (Buffon, however, is not consistent and there are frequent lapses into looser usage; often "nature" is described as if it were an entity consisting of living and inert matter and the laws which govern their behavior.) These natural laws, set in motion by the Creator, continue to operate in an orderly manner by divine consent.[17]

The power of nature is immense, living, and inexhaustible. Its divine origin is manifest in the creation. On earth, man whose power also is of divine origin, is destined to further the plans and intentions of nature. In this teleological conception, nature is virtually personified. Man is a "vassal of heaven," a "king on earth," and his position on earth is central and crucial. Man can bring order to it, improve it. By increasing his own numbers he increases nature's most precious productions.[18]

Buffon classified substances observed on earth into inert matter and living nature. The inert matter consists not only of basic substances like sand, clay, and the metals, but of matter derived in whole or in part from living organisms like marls, chalk, and peat, and matter of volcanic origin.[19] Buffon was much more interested in living nature (*la nature vivante*). To him, it is expansive, creative, fecund. He saw little wisdom in comparing organic life with a machine or in the use of deductive methods in the sciences of nature. In his enthusiasm for observation and experiment he found little that was creative in the Cartesian faith in *a priori* reasoning.[20]

Both the abbé de Pluche's *Spectacle de la Nature*, written in the early part of the eighteenth century—and rivaling Buffon's *Histoire Naturelle* in popularity—and Buffon's own work had done much to shift the emphasis in the study of natural history from the marvels and oddities of nature to the study of the processes, regularities, and natural laws governing life.[21]

In nature, "it seems that all that which can be is." The hand of the Creator has not been niggardly in bestowing life on a limited number of species; on the contrary, the world is full of life and of form.[22] Buffon expresses here an idea which Lovejoy has called "the principle of plenitude": the tendency of life to expand and to fill up nature, to realize in actuality all of its potential forms.[23] This principle and the idea of a chain of being were widely used by natural historians of the eighteenth century to explain the continuity, fullness, richness, and variety of life.[24]

Nature, however, has undergone great changes throughout earth history. Man had been created last—Buffon says he came to this conclusion independent of scripture—for man took the scepter of the earth when it became suited to his empire. We can thank the Creator, he continues in a passage suggesting the doctrine of final causes of which he was so critical, that man had not witnessed the terrible scenes of past epochs (the volcanos, earthquakes, and floods) which announced the birth of intelligent and sensible nature.[25]

Finding a place for man in nature was easier in Buffon's time than in our own. When considered as an animal, Buffon includes him in the chain of being; but his soul and intelligence set him apart from the lower orders. Buffon repeatedly emphasizes the great gap between the highest forms of animal life and the lowest forms of human life represented by the primitive peoples described in the voyages and travels. Echoing ideas expressed in classi-

[17] *HN*, Vol. 12, p. iii ("De la Nature. Première Vue").

[18] *Ibid.*, p. xi.

[19] *HN*, Vol. 13, p. xi ("De la Nature. Seconde Vue").

[20] Piveteau, *OP*, p. xiii. On Buffon's criticism of Descartes and mechanistic ideas, see *HN*, Vol. 2, pp. 50–53 ("Histoire Générale des Animaux," Chap. 3, *ad fin.*).

[21] Mornet, *op. cit.*, pp. 9, 13–14, 33–34.

[22] *HN*, Vol. 1, p. 11 ("De la Manière d'Étudier & de Traiter l'Histoire Naturelle"). "Il semble que tout ce qui peut être, est; la main du Créateur ne paroît pas s'être ouverte pour donner l'être à un certain nombre déterminé d'espèces."

[23] Lovejoy, *op. cit.*, traces the idea to Plato with very important additions being made by Plotinus. See pp. 50–55, 62–66, and the index for its history in the Middle Ages and in modern times.

[24] *Ibid.*, pp. 252–255.

[25] *HNS*, Vol. 5, p. 164 (*EN*, 4th Epoch *ad fin.*).

cal times, Buffon says that the head of man can look to the heavens; he has an erect carriage and an attitude of command. Man possessing an animal body, and yet sharply distinct from animals themselves, is a reasoning, reflecting, educated and educable tool user, who has been able to change nature to his own purposes and uses.[26]

In spite of differences among men, Buffon believed in the common origin and the unity of the human race; in this belief, he followed Christian tradition. The distinctive colorings of the races were caused by climate which explained also the reason that the black race was not found in the New World tropics whose climate was more temperate than that of the Old World tropics. In the latter, the effective heat reaching the earth's surface was greater and the atmosphere was drier; hence the blackness of the skin. In the New World, the east winds (the tropical easterlies or the trades), gathering moisture as they crossed the sea, were cool when they reached the shores of South America; in their further westward course they reached the Andes where they were forced to give up their moisture. The climate therefore was neither dry enough nor warm enough to produce a black skin. These color differences among the races were superficial, Buffon thought, compared to the similarities based on the common origin of the human race.[27] "L'homme, blanc en Europe, noir en Afrique, jaune en Asie, et rouge en Amérique, n'est que le même homme teint de la couleur du climat."[28]

Furthermore, the diet and the manner of living influenced the nature of a people, although one could discern in both the indirect influence of climate. It would be wrong, however, to conclude from these and similar passages that Buffon dogmatically applied theories of climatic influence to explain cultural and physical differences.

Buffon stressed the ability of men to live in and adapt themselves to many climates, but he thought men were more efficient in adapting themselves to the extremes of cold than to those of heat. The history of man's migrations and dispersions showed how ancient this adaptability was; in his migrations, taking with him his arts, his techniques of agriculture and knowledge of plant and animal domestication, he could transform nature in each new area in which he settled in accordance with the tastes he had acquired. With time, with new discovery and exploration, he would be living throughout the whole habitable world, creating a nature in great contrast to the world of primeval nature.

Man is not only adaptable; he is intelligent, inventive, and able to profit from the accumulated knowledge of the past. These qualities enable him to exercise an immense power in changing nature. Man is a creative being whose accomplishments not only accumulate with time but expand through space. Buffon repeatedly distinguishes between man and the animals in this respect: their life, their manner of living, their habitats and their geographic distribution are governed much more by the environment than is the human wanderer who intrudes upon them, changing their lives and habitats, if indeed he condescends to spare them.

The theme of migrating and adaptable man thus is set in sharp contrast with the theme of the less mobile plants and animals whose distribution, if uninterfered with by man, is controlled by climate. It is part of a primordial harmony characteristic of the creation. "It would seem that nature had made the climate for the species or the species for the climate in order to obtain more *rapport*, more harmony in its productions," a truth applying even more forcefully to vegetation, for each region (*pays*) and each degree of temperature has its own kind of plant life.

Buffon also made use of the idea of the vertical zonation of plants as further illustration. This idea, worked out later in detail by von Humboldt, was well known to students in the eighteenth century from the studies of such natural historians as Linnaeus and Tournefort.[29] Buffon illustrated the principle by pointing out that at the foot of the Alps one

[26] *HN*, Vol. 2, pp. 438–439 (*HNH*, "De la Nature de l'Homme") and pp. 518–519 (*De l'Age Viril*). See also *HN*, Vol. 4, pp. 5, 69–70 ("Discours sur la Nature des Animaux. Homo Duplex").

[27] *HN*, Vol. 3, pp. 446–448; 481–484, 511–514 (*HNH*, "Variétés dans l'Espèce Humaine").

[28] *HN*, Vol. 9, p. 2 ("Le Lion").

[29] *HN*, Vol. 6, pp. 55–59. The translated quotation is from p. 57 (*AS*). The whole statement is important in the history of ideas of the geographic distribution of animals. See also *HN*, Vol. 14, pp. 311–317 (*DA*).

finds the flora typical of France and Italy, while the plants on the summits resemble arctic flora.

Regions which had never been inhabited by man, however, had little attraction for Buffon. On their heights were the dark, thick forests, their debris covering the forest floor and choking out all life. There were the stagnant waters, the fetid marshes of their lowlands, useless alike to inhabitants of land or water. And between them was a wasteland of thickets and useless brambles having nothing in common with the meadows of inhabited lands.

No doubt Buffon shared a widespread eighteenth century attitude toward nature, a nature in the words of Roger Heim, well cared for, ordered, a little too well raked, embellished with decorations.[30] It is, however, the same feeling which one observes in the English writers of an earlier date, like Ray and Sprat. They desired to win new land from the moors, the fens, the old forests. They gloried in the ideal of a beautiful village resting in well-tilled fields. They had faith in technology and in the possibility of improving the individual and society. They admired science and its methods and applauded the advances of knowledge; they saw that nature also could be improved with this new knowledge, itself the product of an awakened curiosity.

In his essay on nature, Buffon, a lover of exclamation points, writes, "Qu'elle est belle, cette Nature cultivée! que par les soins de l'homme elle est brillante et pompeusement parée!" Man is nature's most noble product; and nature, cherished by man, multiplies itself in desirable ways under his care. Flowers, fruits, grains, useful species of animals have been transported, propagated, and increased without number; useless species have been eliminated. Mining has advanced. Torrents have been restrained and the rivers directed and controlled. The sea has been conquered. Land has been restored and made fertile. The laughing meadows, the pastures, the vines and the orchards of the hills whose summits are crowned with useful trees and young forests, the great cities arising on deserted places, roads and communications are but a few reminders "of power and of glory, showing sufficiently that man, master of the domain of the Earth, has changed it and renewed its entire surface and that he will always share the empire with Nature."[31] If the style of this quotation seems pompous to the modern taste, the ideas which it contains are worth expressing: the activity of man in artificially multiplying domesticated plants and animals and in replacing one kind of vegetation with another, and the importance of cultural diffusion in distributing them throughout the world.

Buffon's descriptions of primeval nature are as grim as many which followed the publication of the *Origin of Species*. They lack the sense of the unceasing and unrelenting struggle for existence emphasized by Huxley, but they carry a warning similar to his, that man reigns over nature by right of conquest and nature will reclaim her rights, efface the works of man, if he becomes lazy or falters through war, poverty, or depopulation.[32]

THE HISTORY OF NATURE

To Buffon the history of the earth is like human history: both can be reconstructed by examining the inscriptions, monuments, and relics of the past. In addition, physical phenomena, like the social, are subject to continual change; the earth and life upon it therefore assume different forms in different periods. "The state in which we see nature today," he says in the introduction to *Des Époques de la Nature*, "is as much our work as it is hers. We have learned to temper her, to modify her, to fit her to our needs and our desires. We have made, cultivated, fertilized the earth; its appearance, as we see it today, is thus quite different than it was in the times prior to the invention of the arts." And again, "One must seek out, see nature in the newly discovered regions, in the countries which have never been inhabited, to form an idea of its former state, and the latter is still quite modern compared with the ages in which the continents

[30] Heim, "Préface à Buffon," in Bertin, p. 7. This is an excellent general and sympathetic statement on Buffon as a man.

[31] *HN*, Vol. 12, pp. xiii–xv ("De la Nature. Première Vue"). The quotation in French is on p. xiii, the translated quotation on p. xiv.

[32] *Ibid.*, pp. xiv–xv. Thomas H. Huxley, "Evolution and Ethics. Prolegomena," in *Evolution and Ethics and Other Essays* (New York, 1896), pp. 9–11.

were covered with water, fish swam on our plains, or the mountains formed reefs in the seas."[33]

This earth history is the subject matter both of the *Histoire et Théorie de la Terre* with its added notes, proofs, and revisions, and of Buffon's masterpiece, *Des Époques de la Nature*, which divides earth history into seven epochs. These are (1) the formation of the earth and the planets, (2) the consolidation of the rock in the interior of the earth, (3) the invasion of the continents by the seas, (4) the retreat of the seas and the beginning of volcanic activity, (5) the north as the habitat of elephants and other animals of the south, (6) the separation of the continents, and (7) the power of man aiding that of nature. In the seventh epoch, there begins that "seconding of nature" which leads to the transformation of the earth.[34] Buffon's reconstruction of this early period of human history may be summarized as follows: man had appeared when the worldwide catastrophic convulsions of the preceding epochs in earth history had not yet quite subsided. Even the first men, living under the terror of earthquakes, volcanos, and wild animals and without the blessings of civil society, were forced to adapt nature to their needs, to unite for self-defense and mutual help in making houses and such weapons as hard flints shaped like an ax. Early men may have obtained fire from flints or from volcanos and burning lavas to communicate with one another and to make open clearings in the thickets and the forests; with the help of fire, the land was made habitable, while with their stone axes, they cut trees, working the wood into weapons and other tools which pressing need suggested to them. In their inventiveness, they could devise weapons to strike at a distance. Gradually family-groups consolidated into small nations, and those whose territories were limited by the waters or hemmed in by the mountains became so populous that they were forced to divide up their lands among themselves. "It is at this moment [*i.e.*, with the land division] that the Earth became the domain of man; he took possession of it by the labor of cultivation, and from this one can trace the subsequent appearance of attachment to one's native land and to civil order, administration, and law-making."[35]

This description of the activities of early man strongly resembles—in outline if not in actual details—Lucretius' famous account of the early development of human culture.[36] In his writings, Buffon clearly appreciated the role of fire in human history. Firing and clearings are mentioned often in the literature relating to the New World, and they were commonplace practices in the Europe of his day. Buffon's description suggests also the conclusions of modern research in demonstrating the ease with which early man, with simple tools and the use of fire, can make important, lasting, and widespread changes in the environment. To Buffon, early man is something else than a frightened animal adapting himself to a terrifying environment.

These efforts of early man, however, were slight compared with the accomplishments of a civilization which Buffon believed to have existed about 3000 years before his time from the fortieth to the fifty-fifth degree of north latitude in Central Asia. Buffon was impressed with the report of Peter Simon Pallas, the German natural historian, of evidences of cultivation, arts, and towns scattered in this

[33] *HNS*, Vol. 5, pp. 1–5; the quotations are translated from pp. 3 and 4, respectively. (*EN*, intro.)

[34] In 1779, Nicholas Gobet made certain charges against Buffon, given added weight by the notice of Abbé Grosier, that he had profited greatly from Boulanger's *Les Anecdotes de la Nature*. This accusation of plagiarism was important to me because of the theme of this paper, that Buffon, especially in the *Des Époques de la Nature*, showed a remarkable appreciation of the cultural influences on environmental change. The validity of these charges could not be examined thoroughly until Jacques Roger discovered in recent years a 614-page copy of the Boulanger manuscript. From Roger's analysis of the manuscript it is clear that Boulanger was not concerned with the role of man in changing the environment; he was a confirmed and strict believer in the theory of climatic influences. Jacques Roger, "Un Manuscrit Inédit Perdu et Retrouvé: *Les Anecdotes de la Nature* de Nicolas-Antoine Boulanger," *Revue des Sciences Humaines*, Nouvelle série, fasc. 71 (July–September 1953), pp. 231–254. On Boulanger's theories of climatic influence, see pp. 251–252. The borrowings, both in the *EN*, were concerned mainly with part of a description of the mountain of Langres and the commentary on Genesis, pp. 253–254. Roger reproduces the pertinent statements from Gobet, Abbé Grosier, and Buffon's reaction to the charges, pp. 232–234.

[35] *HNS*, Vol. 5, pp. 225–227 (*EN*, 7th Epoch, intro.).

[36] Lucretius, *De rerum natura*, V. 1245–1457.

part of Asia, which Pallas thought were survivals of an ancient and flourishing empire; perhaps Buffon is also anticipating one of the major interests in the 19th century study of man, the search for the Aryan homeland. According to Buffon's theories of historical geology, this region (southern Siberia and Tartary of his day) was best suited to the development of civilization because it was in a relatively tranquil part of the earth, sheltered from inundations, distant from terrifying volcanos and earthquakes, more elevated and consequently more temperate than the others; in "this region in the center of the continent of Asia" with its pleasant climate, clear skies for observing the stars, and fertile earth to cultivate, men attained knowledge, science, and then power. This ancient civilization was destroyed by a people driven out of the north by overpopulation; here Buffon uses the old idea of the northlands as an *officina gentium* advanced as early as the sixth century by Jordanes. Many of the achievements of this civilization were lost, but agriculture and building techniques survived intact and were diffused and improved, their progress following the great centers of population: first, the ancient Chinese Empire and then Atlantis, Egypt, Rome, and Europe. "It is thus only about thirty centuries ago that the power of man was combined with that of nature and spread over the greatest part of the Earth." Among these great and purposeful changes were the domestication of animals, the drying up of marshes, the control of river courses and elimination of cataracts, forest clearance, and land cultivation. With art, science, and exploration, even isolated parts of the world have become his domain; "finally the entire face of the Earth bears today the stamp of the power of man, which although subordinate to that of Nature, often has done more than she, or at least has so marvellously aided her, that it is with the help of our hands that she has developed to her full extent and that she has gradually arrived at the point of perfection and of magnificence in which we see her today."[37] These strong words represent Buffon's true belief in the creative power of man; if he often faltered in his faith in human nature and despaired of man's destructiveness and his propensity to war, it nevertheless was the nature "si merveilleusement secondée" by man that had meaning for him, a transformed nature that was living proof of man's place in the natural order and of his power in molding it to his desires.

[37] *HNS*, Vol. 5, pp. 228–237 (*EN*, 7th Epoch). The quotations are translated from pp. 236, 237.

ON THE FORESTS

Since the latter part of the nineteenth century, the literature devoted to environmental change through human agency has been concerned with an ever-widening variety of themes; before this period, however, forest clearance undoubtedly was the most striking of all the human modifications of the physical environment. Even Marsh's *Man and Nature* (1864) emphasized the effects of deforestation far more than any other changes. Forests were important because of the many economic activities carried on within them; cleared, they had become arable fields, vineyards, orchards.

That Buffon, himself a farmer, nurseryman and plant breeder, an experimenter in forest plantings, should have something to say about forests is to be expected; what he has to say, however, at first appears contradictory, for he advocates both the destruction and conservation of the forests. This seeming inconsistency can be explained by analyzing the role of the forest in Buffon's theory of the earth.

Buffon advanced as one of the five basic facts about the earth the proposition that the heat emitted by the sun and received by the earth is quite small in comparison with the earth's own heat and that solar heat alone would be insufficient to maintain living nature.[38] The internal heat of the earth is being dissipated and it therefore is imperceptibly but relentlessly growing colder, the sun's heat alone being insufficient to arrest this tendency. Buffon underestimated the amount of solar radiation and he knew nothing of the greenhouse effect. Since he knew of the heat of the earth's interior, as experienced in deep mine shafts, he concluded that the heat loss from the earth exceeds the heat gain from the sun. Man can therefore increase the effectiveness of solar heat by deforestation, permitting the sun's heat to reach and warm up the surface of the earth, thus compensating, at least in part, for the heat lost due to the cooling of the earth.

[38] *HNS*, Vol. 5, p. 6 (*EN*, intro.).

One basis for this theory was the reports from the New World that the climate became warmer after forest clearance. Buffon was impressed with a paper which Hugh Williamson had read before the American Philosophical Society on August 17, 1770, and which was later translated into French. Williamson's work illustrates how areas newly settled by Europeans were regarded as outdoor laboratories which promoted scientific discovery. One of his theories was that the winters of Pennsylvania and the neighboring colonies had become warmer within the last forty to fifty years. The northwest wind of the colonial winter, Williamson said, blows from the cold land to the warmer Atlantic. He then asks the question: what would reduce the violence of this wind? His answer, in part, is that in winter a cleared field is warmed up more than is a similar area covered with bushes or trees. The temperature difference between the clearings and the Atlantic is therefore decreased, thus reducing the frequency, violence, and duration of the winter wind. Climates thus modified by human activities can affect the croplands of a country; the health of the people can also be improved by drying up the marshes.[39]

[39] Hugh Williamson, M.D., "An Attempt to account for the CHANGE of CLIMATE, which has been observed in the Middle Colonies in North-America," *Transactions of the American Philosophical Society*, Vol. 1 (Second edition corrected, 1789), pp. 336–345. Hugues Williamson, "Dans lequel on tâche de rendre raison du changement de climat qu'on a observé dans les Colonies situées dans l'intérieur des terres de l'Amérique septentrionale," *Journal de Physique (Observations sur La Physique, sur l'Histoire Naturelle et sur les Arts)*, Vol. 1 (1773), pp. 430–436. The quotation from Williamson given at the end of *Des Epoques de la Nature* is an inexact quotation from the French translation. *HNS*, Vol. 5, pp. 597–599 (*EN*). Williamson finds corroborating evidence in his belief that the climate of Italy in his day is much milder than it was in Virgil's time. To those who deny that such a change has taken place, Williamson replies that it is not a problem to be solved by studying Italian conditions but by observing the effects of the clearing and cultivation of Hungary, Poland, and Germany. These new surfaces have tempered the northwinds which blow south into Italy. Climatic change in Italy is a consequence of the clearing and cultivation of Central Europe. Williamson also deals with the objection that the summers will become too hot with clearing, pp. 342–343. The article is noteworthy because it stresses the relation of forest clearance to the general circulation of the atmosphere.

Combining his theory with the reports on climatic change, Buffon concluded that it was possible for man to regulate or to radically change the climate.[40] In proof he chose an unfortunate example. Paris and Quebec, he said, have about the same latitude and elevation. (Buffon knew that latitude and elevation alone do not determine the climate as he here assumed they do.) Paris would be cold, like Quebec, were France and the countries bordering upon it deprived of their population, covered with forests and surrounded by waters. By making a country healthful, that is, by clearing away the accumulated dead organic matter, draining swamps, cutting down trees and settling people on its lands, it will be provided with sufficient heat for several thousand years. According to his reasoning, Buffon said, France in his day should be colder than were Gaul and Germania 2000 years ago, but it is not because the forests have been cut, the marshes have been drained, the rivers have been controlled and directed, lands covered by the dead remains of organic life have been cleared; if these changes had not been accomplished, modern France would be even colder than Gaul or Germania had been.[41] In further proof, he cites the deforestation, scarcely a century earlier, of a district around Cayenne (there are many references to French Guiana throughout the *Histoire Naturelle*), which caused considerable differences in air temperature, even at night, between the cold, wet, dense forest into which the sun seldom penetrated and the clearings; rains even began later and stopped earlier in them than in the forest. Man's power, however, is limited. He can make warm air ascend but he cannot make cold air descend. His power of lowering the temperature of the hot deserts is thus largely confined to creating shade; it is easier to warm up the humid earth of a dense forest by clearing than it is to plant trees in Arabia to cool the hot dry sands. For such environments, he suggested that a forest in the midst of scorching desert might bring rain, fertility, and a temperate climate; this idea was based on the very old belief that trees attracted clouds and moisture.[42]

[40] This discussion is based on *HNS*, Vol. 5, p. 240 (*EN*, 7th Epoch).

[41] *Ibid.*, pp. 240–241.

[42] *Ibid.*, pp. 241–243.

With the exception of the hot deserts, Buffon thought it important to increase temperature at the surface of the earth because all life is dependent upon heat. In making solar heat more readily available at the earth's surface, man can modify what is harmful to him by opening up useful clearings. "Happy are the countries where all the elements of temperature are balanced and sufficiently well combined to bring about only good effects! But is there any one of them which from its beginnings has had this privilege, any place where the power of man has not aided that of nature?"[43] Thus by systematic deforestation, or planting where called for, man could convert lands of unequal endowment to lands of temperate qualities. Men's bodies—tiny furnaces they were—even heated up the earth, and man's use of fire increased the temperature of every place he inhabited in numbers. "In Paris, during severe cold spells, the thermometers in the Faubourg Saint-Honoré [in the northwestern part of Paris] register two or three degrees colder than in the Faubourg Saint-Marceau [in the southeast] because the northwind is modified in passing over the chimneys of this great city."[44]

Buffon saw no good in thickets, dense forests, accumulated organic debris, poisonous swamps fundamentally, I think, because (in an era long before the microbiology of the soils was understood) he believed they safeguarded moisture at the expense of heat. Forests kept away heat necessary to the maintenance and multiplication of life; they were inimical to nature and to civilization. The role of man, both in the past as in the present, has been one of creating harmonious balances in nature in places where they were needed.

Buffon, however, would not have advocated the deforestation of a modern country. His interest in forests began early in life; he had studied and experimented and he had read well-known English books on forestry like John Evelyn's *Silva: Or a Discourse of Forest Trees*. Like many French writers before him, he warned of the perils in deforesting his country. His essay on the conservation of forests (1739), combining exhortation with practical advice, was a plea for conservation, for better administration and better regulation, for satisfying the needs of the present while not forgetting the welfare of posterity. All forest projects could be reduced to two tasks: "to conserve those which remain, to renew a part of those we have destroyed."[45] French forests in the old *pays* of Brittany, Poitou, La Guyenne, Burgundy, and Champagne had been destroyed to be replaced by wasteland and thickets; these lands should be restored.[46] In 1742, he complained that men had learned through observation and experiment much about the practical arts like agriculture but they knew little of forestry: "nothing is less known; nothing more neglected. The forest is a gift of nature which it is sufficient to accept just as it comes from her hands." Even the simplest ways of conserving forests and of increasing their yield were ignored.[47] He showed continuing interest in the effects of local deforestation when he took part, around 1778, in the *Compagnie pour l'Exploitation et l'Épuration du Charbon de Terre*, an organization interested in coal as an industrial resource, in coke making, and in relieving the drain on the forests of the kingdom.[48]

His attitudes toward the forests can be reconciled in this way: large areas inimical to man had to be cleared to make the earth habitable, but once societies were established on them, the forests were resources which had to be treated with care and foresight.

THE SOILS

Buffon classifies soils into three groups: clays, calcareous earths, and vegetable earths (*terre végétale*) composed mostly of the detritus of plants and terrestrial animals. There are two kinds of this vegetable earth: leaf mold (*terreau*) and *limon*, the residue

[43] *Ibid.* The translation is from p. 246.

[44] *Ibid.*, p. 243.

[45] *HNS*, Vol. 2, pp. 249–271. The quotation is on p. 251. This work, "Sur la Conservation & le Rétablissement des Forêts," is reprinted from *Histoire de l'Académie Royale des Sciences, Mémoires*, 1739, pp. 140–156.

[46] *HNS*, Vol. 2, p. 259.

[47] *HNS*, Vol. 2, pp. 271–290. This work, "Sur la Culture & Exploitation des Forêts," is reprinted from *Histoire de l'Académie Royale des Sciences, Mémoires*, 1742, pp. 233–246.

[48] Bertin quotes a passage from the Mémoires de Bachaumont (1780) in which he mentions government interest in treating coal as a means of arresting the degradation of the forests of the kingdom caused by forced cutting owing to the excessive use of wood in domestic hearths and in the industrial arts (pp. 212–213).

representing the final stages in the decomposition of the leaf mold. These soil types are seldom found in pure form in nature. Soils are mixtures of them, a soil concept neglected by chemists and mineralogists who, he says, study the clays and the calcareous earths, slighting the vegetable earth.[49]

This vegetable earth is always thicker in uninhabited virgin lands than in inhabited countries, for it naturally increases in places from which man and fire (his agent of destruction) are absent. The thick centuries-long accumulations of vegetable earth are confined to virgin lands. Vegetable earth is thinner on mountains than in valleys or plains because the *limon* is washed down from the highlands by streams and deposited on plains. This soil would remain fertile if it were not overworked; where it has been destroyed, only dry sands or bare rocks remain, unlike the rich leaf mold and *limon* of the virgin lands.[50] In inhabited regions, the vegetable earth is more thoroughly mixed with the vitreous sands and the calcareous gravels because the plowshare turns up the lower layers of the inorganic soils. This thin layer of vegetable earth which covers the earth's surface is "le trésor des richesses de la Nature vivante," the "magasin universel des élémens [sic] qui entrent dans la composition de la plupart des minéraux."[51] These organic soils contain minerals which, like iron, give the yellow stain to *limon*. They are vital to mankind because they contain in abundance all the four elements (air, water, earth, fire—the classical doctrine of the four elements still dominated the chemistry and soil theory of the day) as well as organic molecules. For this reason the soil has become "la mère de tous les êtres organisés, et la matrice de tous les corps figurés." These matters are often better understood, says Buffon, by the farmer in the fields than by the naturalists.[52]

In inhabited countries, especially where the population is numerous and all lands are cultivated, the quantity of vegetable earth diminishes century by century because fertilizers do not restore as much to the soil as is taken from it and because the greedy farmer or the short-term owner, more interested in reaping benefits than in conserving soils, exhaust and starve them and make them carry more than they can.[53]

One obtains higher yields by working the soil over and over again until it becomes comminuted but then both the fine and heavy particles are more easily washed away by streams. "Each summer thunderstorm, each heavy rain of winter loads all the waters with yellow *limon*;" so often and so great are the losses that they cannot be remedied by soil fertilizers and one cannot help but be surprised that sterility has not come sooner, especially on hillside slopes. Rich soils which have become poor through cultivation will gradually be abandoned; such land must be left fallow to allow the beneficent forces of Nature to repair the damage and "work to re-establish what man never ceases to destroy."[54] Buffon was also interested in fertilizers; he saw a close relationship between soil improvement and the manure of the sheep folds.[55]

It is remarkable that Buffon makes the sharp distinction between soils formed by natural processes and those which have been altered through cultivation. This genetic approach to soil study resembles the investigations of Dokuchaiev and his school in Russia, and of Hilgard in America in the nineteenth century more than it resembles Western European soil investigations which at least to the time of Liebig were primarily concerned with the practical problems of soils under cultivation.

ON DOMESTICATIONS

Buffon was convinced that plant and animal domestications had been the most important means by which man had changed virgin nature into environments suitable for high civilization. His ideas on their importance remind one of the first chapter of the *Origin of Species* in which Darwin shows how great the power of natural selection must be if one reflects on the enormous changes which infinitely less powerful man brings about in nature through his successes in plant and animal breeding.

[49] *HNM*, Vol. 1, pp. 384, 388 (*TV*).
[50] *Ibid.*, pp. 389–390.
[51] *Ibid.*, p. 416.
[52] *Ibid.*, pp. 424–425. The quotation is on p. 424.
[53] *Ibid.*, p. 425.
[54] *Ibid.*, p. 426.
[55] *HN*, Vol. 5, pp. 3–6, 19–20 ("La Brebis"). One hundred sheep in one summer could improve 8 *arpents* of land for six years. An *arpent* is about 1.5 acres.

Buffon accepts a utilitarian theory of domestication which originated in classical times; man purposefully and self-consciously domesticates animals because they have qualities of use in the human economy—the suitability of the ox as a draft animal, of the dog as a shepherd, of the sheep as a supplier of wool. Man has chosen only a few; he has used but a fraction of what nature is capable of giving him. Awaiting him in reserve are other possible domestications, for man does not know sufficiently well what nature is capable of nor how much he can get from her. Instead of embarking on new researches, he prefers to misuse the knowledge he has acquired.[56] The utilitarian theory of domestication persisted far beyond Buffon's time until it was effectively challenged by Hahn's theories of domestications of animals for ceremonial reasons.

Domestic animals provided man with the necessary help in transforming and controlling all nature. They had another enormously important effect: man had increased and multiplied, almost at will, the populations of domestic plants and animals, whose lives and reproduction took place under carefully controlled conditions; in undisturbed nature, on the other hand, reproduction was subject to the hazards of predation, climatic, and other environmental conditions.[57]

In Buffon's language, the domesticated animals were almost like feudal serfs; they owed much to man, returning their labor, flesh, and their products for shelter and food. As they multiplied and were diffused throughout the earth, they took over the habitats of the wild animals. Buffon even credits man with the extinction of the gigantic animals whose bones were still being found; voracious and injurious species have also been destroyed or reduced in number. Man has set the animals against one another, controlling some by skill, others by force, and still others by dispersing them. Man's empire is now bounded only by inaccessible places, remote wildernesses, burning deserts, icy-cold mountains, and obscure caverns which become retreats for a small number of indomitable animal species that cannot be subjugated.[58] The artificial distribution of the domesticated animals is different from the natural distribution of the wild animals, living in well-defined and climatically controlled habitats.[59]

Another living nature has been created, that of man and his domesticated plants and animals, propagated by him, accompanying him on his migrations throughout the world, helping to create new environments for civilization at the expense of pristine nature and so escaping in part its inexorable laws of birth, reproduction, and death. Man with his plants and animals displaces natural plant and animal habitats, often disturbing or destroying the societies of the bees, the ants, the beavers, and the elephants. Through his own reproduction and the reproduction of useful domestic species, man multiplies the quantity of certain kinds of life and the amount of activity and movement, ennobling all life, including his own, in the process because under his intelligent leadership a higher form of organized existence has been created. The domestications, permitting the multiplicaton and expansion of the human race, brought on further conquests of nature to enable man to produce abundance everywhere. Millions of men, he said, now exist in the same space which in former times was occupied by two or three hundred savages.[60] Similar increases in densities occurred with the replacement of a few wild animals by thousands of domesticated animals.

Through the agency of man, the kind and quality of life on earth have been radically altered, a pregnant idea when one considers that many modern evolutionists with a knowledge of genetics denied to Buffon have emphasized the directive influences of man on his own evolution and on the evolution of the plants and animals.[61]

Buffon attached great importance to the

[56] *HN*, Vol. 12, p. 96 ("L'Élan et le Renne").

[57] HN, Vol. 4, pp. 169–171 (*AD*, intro.); *HN*, Vol. 14, pp. 326–328 (*DA*); *HN*, Vol. 11, pp. 352–354 ("Le Mouflon").

[58] *HN*, Vol. 4, pp. 171, 173 (*AD*, intro.). See also *HNS*, Vol. 5, pp. 246–248 (*EN*, 7th Epoch).

[59] *HN*, Vol. 14, pp. 311, 316–317 (*DA*). The first paragraph distinguishes between the climatic influences on man and on the plants and animals. In the fourth paragraph there is an important statement regarding the differences in distribution between the wild and the domestic animals.

[60] *HNS*, Vol. 5, p. 248 (*EN*, 7th Epoch).

[61] *Ibid.* See George G. Simpson, *The Meaning of Evolution*, Mentor Books (New York, 1951), p. 110.

"degeneration" of animals; by this term he meant the variability of a species under the influence of climate and food; in the case of the domestic animals, there was the added influence of the "yoke of slavery."[62] Degeneration was even more marked among the domestic animals reduced to slavery (a favorite word of Buffon's) whose history was much more complicated than that of wild animals because their lives and the perpetuation of the species were so artificially controlled. He saw the advantages of deliberate crossing of animals. The inevitable promiscuity in mixed grazing should be avoided and enclosures encouraged in the interests of careful animal breeding. He remarked that the color of domesticated animals is often more vivid than that of wild animals.[63] There is so much variety in the horns of domestic cattle that it is now impossible to discover the "model of nature" from which they were derived. The amours of domesticated animals are in marked contrast with those in nature. Castration, the selection of a single male for breeding purposes, the transportation of domestic animals from one climate to another are other important causes of the degeneration of animals under domestication.[64]

Buffon thought the weakest of the useful animals were domesticated first, the sheep and goat coming before the horse, ox, or camel. The priorities, however, are confused, for elsewhere he describes the camel as man's oldest, most laborious, and most useful slave. The camel has no wild counterparts because its natural habitat is in a climate where human societies have first developed, and apparently only the domesticated ones have survived. Its good qualities have come from nature, its bad from its sufferings at human hands.[65]

The reindeer, Buffon said, formerly lived in France, especially in the high mountains. It could do so because France at a remote period was cold and humid. Its climate was similar to that of the reindeer's present northern habitat. With the cutting of the forests, the draining of swamps, the multiplication of men, and of their manifold activities and their increased consumption of every description, the reindeer was forced to desert an environment in which it could no longer exist; it migrated northward where, because of its qualities, it was domesticated by the Laplanders who had no opportunities for the other domestications because of the rudeness of their society and the cold climate. If the people of France had also lacked domestic animals, the reindeer would have been domesticated there. Buffon used this history to moralize about the shortcomings of man in making use of the opportunities offered to him by nature.[66]

To Buffon the noblest animal domesticated by man was the horse, but even this courageous and intrepid being was obedient and docile; one could see these marks of servitude well by observing horses feeding in the pastures. He compared the freedom of movement of the feral horses of Spanish America with the lesser qualities of dexterity and agreeableness of the animal under the constant surveillance of man.[67] Sometimes domestications had gone so far as to render the animal virtually helpless in its dependence on man. Buffon questioned whether the sheep with its many useful attributes had ever existed independently of man. The fat-tailed sheep was an even more exaggerated example of this dependence. He had such a low opinion of the ovine intelligence that his English translator, Smellie, found it necessary to come to its defense. According to Buffon, the mouflon, a nobler and more self-reliant animal found in the mountains of Greece, in Cyprus, Sardinia, Corsica, and the deserts of Tartary, was probably the primitive stock from which all the different varieties of sheep had degenerated.[68] The goat, more wild and robust than the sheep, was also more independent of man. Goats could eat a wide variety of plants and were little affected by harsh climates. Under domestication, these

[62] *HN*, Vol. 14, p. 317 (*DA*).

[63] *Ibid.*, p. 324. "L'état de domesticité a beaucoup contribué à faire varier la couleur des animaux, elle est en général originairement fauve ou noire. . . ."

[64] *HN*, Vol. 11, pp. 293–296 ("Le Buffle," etc.).

[65] *HN*, Vol. 11, p. 352 ("Le Mouflon"); pp. 228–229 ("Le Chameau et la Dromadaire").

[66] *HN*, Vol. 12, pp. 85–86, 95–96 ("Le Élan et le Renne").

[67] *HN*, Vol. 4, pp. 174–176 ("Le Cheval"). In this article, Buffon returns to the theme of the lesser influences of climate and food upon the human species than upon the animals, repeating the theme of migrating, adaptable man, pp. 215–223.

[68] *HN*, Vol. 11, pp. 363–365 ("Le Mouflon"). On Smellie's comments, see his translation of Buffon, as cited, Vol. 4, pp. 268–272.

friendly animals multiplied until they became nuisances. Although he mentioned the harm done by goats to the fields and woods, he did not castigate the goat as a destroyer of vegetation as have so many writers of the nineteenth and twentieth centuries.[69]

To Buffon the domestication of the dog was an event of the highest historical importance. In order to realize its significance, one should try to imagine what mankind would have done if the dog, this docile friend of man that was more adaptable than any other animal, had never existed. How would man have conquered and domesticated the other animals? And even now how could he discover, pursue, and destroy wild and useless beasts? To make himself master of living nature and to provide for his own security, man had to intervene in the animal world, winning over those animals capable of attaching themselves to him, obeying him, and thus becoming his agents in controlling the others: "The first art of man thus has been the education of the dog and the fruit of this art [has been] the conquest and peaceful possession of the Earth."[70] With the help of the dog, which was both a shepherd and an intelligent companion on the hunt, man domesticated other animals, gradually attaining greater dominance through more domestication (Fig. 2). Since the original stamp of nature never preserved its purity in beings long under the management of man, the dog exhibited this degeneration to a high degree. Buffon compared the varieties of the dog to those of wheat;[71] both species bore the marks of long human experimentation. The most conspicuous refinements in the art of dog breeding were found in the most advanced societies; the dog also owed many of its most endearing and brilliant qualities to his association wth man.[72] Buffon thought that the

FIG. 2. The Shepherd Dog. The dog helped man to change and to control nature; it played a vital role in the creation of civilization. Drawing by Jacques de Sève from the first edition of the *Histoire Naturelle*, Vol. 5.

shepherd (*chien de berger*) was the domestic variety closest to the wild prototype; in the essay on the dog, he included a diagram showing the degeneration of the domestic dogs from the *chien de berger*. Similarly, the varieties of the domesticated cat, like those of the dog, were most numerous in the temperate climates and in the advanced societies.[73]

It has been the same with plants: the bread grains were not a gift of nature; they were a product of experiment and the application of intelligence to agriculture. Wild wheat was found in no part of the world. The grain with its marvellous characteristics, its climatic adaptability, its keeping qualities has been perfected by man.

The changes which men have made in plant and animal life do not belong to the past alone; they are continuing. One need only compare, he says, the vegetables, flowers,

[69] *HN*, Vol. 5, p. 60, 66, 68 ("La Chèvre").

[70] *HN*, Vol. 5, pp. 186–188 ("Le Chien"). The translated quotation is on p. 188. In this essay, Buffon discusses, at some length, pariah dogs which had been formerly domesticated and had then become feral in deserted or depopulated countries. He thought they could easily be domesticated, considering the dog's fundamental character compared with the wolf. The descriptions of these dogs in America and in other parts of the world convinced Buffon that the *chien de berger* might be the prototype of the wild animal (pp. 191, 197–202).

[71] *Ibid.*, pp. 193–196.

[72] *HN*, Vol. 11, pp. 2–3 ("L'Éléphant").

[73] *HN*, Vol. 5, p. 201. See also diagram, facing p. 228, on the derivation of the domestic breeds from the shepherd. Vol. 6, pp. 16–17 ("Le Chat"). This passage also summarizes man's influence on the nature, habits, even the form of animals.

fruits of today with those of the same species 150 years ago; one can make this comparison by looking at the great collection of colored drawings beginning in the times of Gaston d'Orleans (1608–60) and continuing until Buffon's own day. Some of the most beautiful flowers of that time would be rejected at the later day, not by the florists but by the home gardeners. One can assign a very late date to our better seed and stony fruits; they are actually new fruits with old names.

Buffon marveled at the persistence and patience of man in selecting and developing new plant varieties, his ability to recognize "certain individual plants having sweeter and better fruits than others." This selection, presupposing so much experience and skill, would have been an empty accomplishment without the discovery of grafting which requires as much genius as the first does patience.[74]

The most arresting idea of Buffon concerning domesticated plants and animals is his interpretation of them as secondary creations replacing virgin nature under carefully planned artificial conditions, and paralleling this interpretation, that these domesticated plants and animals, diffused by man, become new centers from which further changes in virgin nature take place.

MAN AND WILDLIFE

Buffon's theory of earth history and his philosophy of man assumed the superiority of a nature which had been improved by human endeavor. He was not, however, insensitive to wildlife; even if his harsh denunciations of the vegetation of virgin nature showed his strong preferences for the ordered nature of human workmanship, he saw "naive beauties in the wild" and was not indifferent to the harm which civilized man had done, even in those parts of the earth in which he was only beginning to make his influence felt.

His praises of the wild animals are in fact transparent criticisms of human society. Have those animals, which we call wild because they have not been subdued, need of anything more than they have to be happy? They are neither the slaves nor the tyrants of their fellow-creatures; the individual, unlike man, does not fear the rest of his species. They are peaceful among themselves and war comes to them only from strangers or from men. They have good reason to avoid man and to establish themselves as far as possible from him.[75] Themes like these occur frequently in Buffon's writings: despite his faith in improvement and his respect for human achievement, he constantly reverts to man's warlike and destructive nature.

Within living nature, in regions remote from human influence, elephant, beaver, monkey, ant, and bee societies flourished. If they were not the product of a reasoning mind, they seemed based on a sense of what was reasonable. As man migrated and settled throughout the earth, the result was to destroy, or at least to partially break up these societies, which, if uninterfered with, led a fairly peaceable existence among themselves. Even if his settlements were remote from their habitats, man's presence caused them to retreat further and further, pressed by fear and necessity, making them not only wilder but diminishing their faculties and talents. In their natural state, they had means of self-protection. "But what can they do against beings who know how to find them without seeing them, to cut them down without approaching them?" The freely migrating, expanding, and deadly human race changed the primeval distributions of plants and with them of the animals. Although he recognized that this triumphant process was indistinguishable from the growth, development, and maintenance of civilization, one often feels in Buffon's writings a sense of sorrow at the indiscriminate destruction of wildlife, so remote from sportsmanlike hunting and the chase. The carnivores, he said, are harmful only because they are rivals of man, and he repeatedly mentions the relationship between human populations and their expansion and the diminution of the larger predators. If in a few centuries the expanding human race settles uniformly throughout the habitable earth, the story of the beaver will

[74] *HN*, Vol. 5, pp. 195–196 ("Le Chien"). This essay has some interesting comments on wheat. See also *HNS*, Vol. 5, pp. 249–250 (*EN*, concluding paragraphs of 7th Epoch). Since the *HN* is an unfinished work, Buffon's remarks about the domestications of plants are very scanty.

[75] *HN*, Vol. 6, pp. 55–56 (*AS*, intro.). This volume was published in 1756.

seem a fable.[76] In the introductory chapter on the carnivores, Buffon discussed sympathetically the wild animal in nature;[77] and in the essay on the lion, he said that species of animals like the lion of no use to man appear to have been reduced in number because man everywhere is more numerous and because he has become more clever and has learned how to make weapons which nothing can resist. Buffon pointed to the diminution in the numbers of the lion as evidence of the falseness of a notion (which Montesquieu had revived in the *Persian Letters*) that the population of the earth was greater in ancient than in modern times. How could one maintain, Buffon asked, that the population of the earth had declined since Roman times if the numbers of lions had been reduced to a fiftieth, or even only to a tenth part of what they were before? The human race had not declined but had increased in numbers; reductions in animal populations could scarcely be compatible with diminution of human populations. With declining human populations their numbers would have increased.[78]

The sloths had been saved from extinction because they avoided places frequented by man and the more powerful animals. Buffon drew two other important conclusions from the existence of sloths: they illustrated the doctrine that in nature everything that can exist does exist, and they showed the absurdity of the doctrine of final causes because of their many crippling physical defects. Buffon thought their extinction at the hands of man inevitable. Man had been largely responsible for the disappearance of the Libyan elephant; the animal had retired in proportion to the interference it had met with from the human species.[79] He also remarked upon the role of man in the worldwide diffusion of the rat.[80] There was less direct influence on birds, but he noticed the effect of man on the songs of birds and their mimicry of him,[81] and the threatened extinction of the ostrich because of the "prodigious consumption" in Europe of its plumes for hats, helmets, theatrical costumes, furniture, canopies, funeral ceremonies, and feminine finery.[82] Neither was the life of the sea undisturbed. The widespread killing of the common seal[83] and of the walrus[84] illustrated trends already observed concerning animal societies on land. The deserted coasts of the newly discovered lands and the extremities of the two continents have become the last haven of the seal, "ces peuplades marines," for they have fled the inhabited coasts and appear only as scattered individuals in our seas which no longer offer them the peace and security which their "grandes sociétés" need. They have gone in search of that liberty—again the allusion to human society is unmistakable—which is necessary for all social intercourse and have found it only in the seas little frequented by man.[85] The volume in which this passage appeared was published in 1782.

NATURAL AND CULTURAL LANDSCAPES

Even if one dismisses the physical theories upon which Buffon's ideas of the necessity of human intervention in the natural order are based, one is impressed with the shrewd, if short and scattered, contrasts which he makes between environments scarcely touched by man and those which had long been the scene of human settlement and activity. In these, he anticipates the ideas of Lyell, von Humboldt, Marsh, Ratzel, and Vidal de la Blache.

Rude and uninhabited lands have rivers

[76] *HN*, Vol. 6, pp. 55–62 (*AS*). The quotation translated is on p. 61; on the beaver, p. 62.

[77] *HN*, Vol. 7, p. 3 ("Les Animaux Carnassiers"). In the introduction, Buffon writes: "Si nuire est détruire des êtres animés, l'homme, considéré comme faisant partie du système général de ces êtres, n'est-il pas l'espèce la plus nuisible de toutes?"

[78] *HN*, Vol. 9, pp. 4–5 ("Le Lion").

[79] On the sloths, *HN*, Vol. 13, p. 40 ("L'Unau et L'Aï"). *HN*, Vol. 11, p. 41 ("L'Élephant"). As he does in his discussion of the lion, Buffon in this essay uses the example of the elephant to argue that the present day population of North Africa is greater than in Carthaginian times.

[80] *HN*, Vol. 7, p. 283 ("Le Rat").

[81] *HNO*, Vol. 1, pp. 21–22 ("Discours sur la Nature des Oiseaux").

[82] *Ibid.*, p. 444 ("L'Autruche"). Buffon has an interesting discussion of the uses of the ostrich by various peoples in historical times (pp. 440–448). See also his remarks on pp. 455–456 ("Le Touyou").

[83] *HNS*, Vol. 6, p. 335 ("Le Phoque Commun").

[84] *HN*, Vol. 13, pp. 367–370 ("Le Morse ou la Vache Marine"). Buffon mentions also the "cruel war" on the manatee whose numbers have been much diminished in places well populated by man. *HNS*, Vol. 6, pp. 382–383 ("Les Lamantins").

[85] *HNS*, Vol. 6, p. 335 ("Le Phoque Commun").

with many cataracts; the land might be flooded with water or burned by drought. Every spot capable of growing a tree has one. Among countries inhabited for a long time, there are few woods, lakes, or marshes, but they have many heaths and shrubs (meaning no doubt that heaths and shrub take over deforested and barren mountain tops). Men destroy, drain, and in time give a totally different appearance to the face of the earth. In general Europe is a new continent; its traditions of migrations and the recency of its arts and sciences indicate that this is so, for not so long ago it was covered by marshes and forests.[86]

In a passage suggesting Lyell's remark that man tends to become a leveling agent, Buffon says that in countries whose population is too small to form and to support advanced societies, the surface of the earth is more rugged and unequal. River beds are wider, more interrupted by cataracts. The Rhone and the Loire are tamed rivers which under natural conditions would require a very long time to be made navigable. Rivers acquire a fixed determinate course when their waters are confined and directed and their bottoms are cleared out.[87] He mentions Tournefort's statement that the famous labyrinth of Crete is not a work of nature alone; old mines and quarries had been dug there and with the lapse of time it is no longer easy to distinguish between a work of nature and a work of man. The Maastricht quarries, the Polish salt mines, the hollows near large cities are other instances of man as an earth mover, although these operations he thought—and how wrongly—would always be minor in the history of nature.[88] In a discussion of the large marshes remaining in the world, he said that the plains of America are one continuous marsh, proof of the newness of the country, of the small number of inhabitants, and still more of their lack of industry.[89]

Buffon's physical theories, his comparative studies of the quadrupeds, his notions concerning primitive society in the New World, and his self-satisfaction with the improvement of nature by man in Europe led him to the curious notion that nature in the New World was weaker and on a lower scale of magnitude than that of the Old World.

The physical explanation of this weakness was based on the same theory as was his explanation of racial differences: the main reason was that the New World tropics were more humid and cooler, owing to the trades and to the Andes, than the Old World tropics. Even though he admitted that the New World produced its share of species of the large reptiles, insects, and plant life, he persisted in his belief that New World nature was weaker because he had proved to his own satisfaction that the animals of the New World were smaller, that wild and domestic animals of the Old World became smaller when they lived in the New, and that there were, on the whole, fewer species in the New.

Primitive man of the New World had, moreover, few talents. He was cruel and indifferent to life and had little ardor for his women. His societies were therefore small, and their increase in population was insufficient to develop the arts. Primitive man in the New World had been unable to play the role of aiding nature and of developing it from its rude state. The reason for the few domesticated animals of the New World was not any lack of docility among the animals, but the weakness of man.[90]

The environmental theory and Buffon's harsh judging of primitive man in the New World explained the contrast between its primeval landscapes and the well-ordered landscapes of the Old. In his failure to clear the forests and to drain the marshes, the American Indian revealed his incapacity to change nature to the degree necessary for a high civilization.

Buffon's claim that nature was weaker in

[86] *HN*, Vol. 1, pp. 210–211 (*TE*, Proofs, Art. 6, "Géographie").

[87] *HN*, Vol. 1, p. 368 (*TE*, Proofs, Art. 10, "Des Fleuves").

[88] *HN*, Vol. 1, p. 549 (*TE*, Proofs, Art. 17, "Des Isles Nouvelles," etc.).

[89] *HN*, Vol. 1, p. 575 (*TE*, Proofs, Art. 18, "De l'Effet des Pluies, des Marécages," etc.).

[90] This general theme of the weakness of man in the New World is repeated many times in the *HN*, but the whole argument is in three articles: *HN*, Vol. 9, *Animaux de l'Ancien Continent*, pp. 56–83; *Animaux du Nouveau Monde*, pp. 84–96, and *Animaux Communs aux Deux Continents*, pp. 97–128. The passages upon which this discussion is based are in the introduction to the animals of the New World, pp. 84–88, and in the essay on animals common to both continents, pp. 102–111.

the New than in the Old World was a disastrous error which affected his reputation in America and strongly influenced contemporary interpretations of the New World environment and its cultures. Many of them cannot be understood without reference to Buffon's thesis; the supposed inferiority of nature was widely applied to the aboriginal peoples and even to the European settlers. Ideas of this kind were disseminated by men like Peter Kalm, Cornelius de Pauw, the Abbé Raynal, and by William Robertson. In 1777 Buffon himself protested against the unsupported views of de Pauw and Kalm.[91] These social theories which were extensions of Buffon's physical theory have been thoroughly studied by Gilbert Chinard.[92] The ablest rebuttal of Buffon was written by Thomas Jefferson.[93] In Buffon's defense it can be said that he considered the theory as evidence supporting his belief that primitive nature requires the ordering hand and intelligent mind of man to improve it and to make it fruitful. These had not been forthcoming in sufficient measure in the New World in pre-Columbian time.

CONCLUSION

In rejecting the idea of final causes, Buffon rejected also the old belief in a divinely designed earth; in emphasizing the power of man in changing nature he offered an alternative to an older environmentalism, even though the latter still persisted in his own

[91] *HNS*, Vol. 4, pp. 525–532 ("Addition à l'Article des Variétés de l'Espèce Humaine. Des Américans").

[92] "Eighteenth Century Theories on America as a Human Habitat," *Proceedings of the American Philosophical Society*, Vol. 91 (1947), pp. 27–57. See especially pp. 30–31 and 42–43 on Buffon and Jefferson; pp. 38–39 on William Robertson's *History of America*; and p. 41 and footnote 19, p. 56 on Buffon and Benjamin Franklin. Many Americans probably felt that European thinkers were overworking theories of environmental influence in explaining conditions in the New World. "The world has been too long abused with notions, that climate and soil decide the characters and political institutions of nations." John Adams, *Works*, Vol. 6, p. 219, quoted by Chinard, p. 45. Chinard suggests that Buffon's thesis may have been responsible for Jefferson's continuing interest in the discovery of gigantic bones. "It may also be that it incited him to make every possible effort to encourage philosophical and 'literary' study of the natives, which later he evidenced in his investigations on the Indian dialects and in his instructions written on the occasion of the Lewis and Clark expedition" (p. 56, footnote 22).

[93] In the *Notes on the State of Virginia* Jefferson condemned the false European notions of the Indian and dismissed accounts of the South American Indians as being too full of fable to be worthy of credence. Too little was known of climate to support Buffon's theories. Who were the travelers who had furnished Buffon information about the quadrupeds? Were they natural historians, did they actually measure the animals they spoke of, were they acquainted with the animals of their own country, did they know enough to distinguish one species from another? "How unripe we yet are, for an accurate comparison of the animals of the two countries, will appear from the work of Monsieur Buffon." Jefferson dismissed as ridiculous the question of the degeneration of European domesticated animals in the New World. If they were smaller, weaker, less hardy, the reasons for their poor condition would be the same in the New as in the Old World: neglect, poor food, poverty of the soil, and poverty of man. Jefferson asked "whether nature has enlisted herself as a Cis- or Trans-Atlantic partisan?" The answer was an emphatic "No."

This necessarily short summary does little justice to Jefferson's painstaking analysis and research on Buffon's ideas. He was equally concerned with the implications of the ideas of the Abbé Raynal. See Saul K. Padover, ed., *The Complete Jefferson* (New York, 1943), pp. 495–611 ("Notes on the State of Virginia, Query VI"). See also Daniel J. Boorstin, *The Lost World of Thomas Jefferson* (New York, 1948), pp. 100–104.

On his visit to France, Jefferson protested to Buffon personally. "I told him also that the reindeer [of the Old World] could walk under the belly of our moose; but he entirely scouted the idea." Jefferson then wrote to General Sullivan of New Hampshire for the bones, skin, and antlers of the moose. Six months later, after much work by General Sullivan and his party and at an expense of forty guineas to Jefferson, the evidence was presented to Buffon who was convinced. "He promised in his next volume to set these things right also, but he died directly afterwards." Had Buffon lived, one wonders if he would have changed his mind about the weakness of nature and of primitive man in the New World; as Jefferson generously grants, and as the *Histoire Naturelle* repeatedly shows, he did not stubbornly stand on his errors. *The Complete Jefferson*, p. 891. In this conversation between Jefferson and Buffon (as related by Jefferson to Daniel Webster) the personalities of both men and their scientific attitudes stand out clearly and vividly. Buffon's faith would have been shaken still more by Darwin's astonishment at the changed state of the American continent which formerly swarmed with great monsters. "If Buffon had known of the gigantic sloth and the armadillo-like animals, and of the lost Pachydermata, he might have said with a greater semblance of truth that the creative force in America had lost its power, rather than that it had never possessed great vigour." Charles Darwin, *Journal of Researches Into the Natural History & Geology of the Countries Visited During the Voyage Round the World of H.M.S. 'Beagle'* . . . . (New Edition; London, 1913), p. 183 (entry of Jan. 9, 1834).

work. To Buffon the changes which man had made on the earth were inextricably woven into the history of civilization. It is true that in the eighteenth century there was nothing novel in the idea that civilization was the result of man's control over nature through theoretical and applied science, but the emphasis of most expositors of this idea was on invention, social change, the purposive applications of scientific truth to practical matters. It was a totally different matter to see, as Buffon had seen, man-made changes in the earth in their historical perspective. The one idea concerned society; the other, earth history.

Buffon's discussions of man as a modifier of the physical environment, however, lack the bitterness, the harsh denunciation of man as a destroyer of nature, the sense of urgency and of fear that were heard with increasing frequency during the last four decades of the nineteenth century, and are continuing to be heard in our own day.

Although Buffon's ideas of geological history were remote from the modern foundations laid by Hutton, Playfair, and Lyell, he realized that the history of the earth had been something more than the creation, the antediluvian world, the deluge, and the postdiluvian world, the only events that were considered by many theorists of the time. His ideas of the length of the geological epochs were, by modern standards, pitifully short but his synthesis provided for the essential elements of time and periodization in earth history, permitting the appearance of man at a late epoch in the history of the earth, and thus allowing sufficient time for the physical changes in the earth brought about by natural causes and by human agency to take place.

Buffon concludes *Des Époques de la Nature* with a plea for the abolition of war and for moral reform to make man's tenure of the earth a benefit to him, affording him, with the abandonment of these destructive activities, an opportunity for an even greater realization of his imaginative and inventive powers. In this exalted plea, Buffon did not suspect that the growth of world population and the relentlessly increasing changes in the physical environment would introduce much greater complications into the still unsolved problems of his own day. Exhortations like Buffon's must now be delivered against far grimmer backgrounds than those of an eighteenth century natural historian who uneasily sensed the coming French Revolution while he confidently welcomed the industrial inventions as another step in the transformation of nature.

As long as man has a civilization he must study its history—not as a pastime—but to preserve it. The age-old themes of man's agency in changing the environment through domestication, agriculture, drainage, clearing, and grazing, so forcefully explored by Buffon, will lose neither their force nor their significance with the passage of time, if they do no more than passively reveal the gulf between one age and another. In all their confusions and ignorance, men have known for a long time that the earth has a history, and that the human race has a history. Buffon's insight was that he saw that the relationship between the two was also a history.

ESTIMATES OF WATER USES IN THE MUSKINGUM WATERSHED CONSERVANCY DISTRICT FOR 1975[1]

MORGAN D. THOMAS

University of Washington

THE last twenty-five years have witnessed the establishment of a growing number of public organizations concerned with water. Watershed conservancy districts, such as the one dealt with in this paper, have been an important type of agency dealing with this resource. Until relatively recently the majority of such districts were created and operated in terms of single-purpose objectives, such as the control of floods, and they were extremely limited in their scope of operations.

Today states such as Ohio acknowledge the fact that watershed conservancy districts can have multi-purpose objectives for their establishment.[2] One of the many functions of a progressive water conservancy district is to plan for the future so as to maintain harmony between the supply of and demand for water in the district. Estimates of future water use patterns are basic data required for such planning.[3]

If estimates of future water use are to be made in an area it is desirable to study the effect of actual and potential changes in (1) the size, structure, and distribution of industry, and (2) the size of the population, and its water-use characteristics. An effort has been made to give consideration to these dynamic aspects in this study.

OBJECTIVES

This paper discusses some of the methods used to estimate water uses in various parts of the Muskingum, Ohio, region in 1975. In addition, it will be shown how estimates were made of employment levels in different industries and the total populations of the region and subregions. An explanation will be given of the reasons for dividing the Muskingum Watershed region into five subregions. Having obtained information on future employment and population levels in the various areal units, an attempt will then be made to relate these data to various water-using characteristics peculiar to individual industries and urban and rural populations. In this way, it is demonstrated how estimates were arrived at for the water-use pattern of each subregion and the region in 1975. It is hoped to show how such information on water use, when associated with information on water supply, can be used to give a rough measure of the balance between water supply and demand in the subregions and region. Finally, an attempt will be made to use this model as an indicator of areas which may have a water supply problem in 1975. In addition, suggestions will be made concerning aspects which require further elaboration, refinement, and research.

SCOPE OF STUDY

It is appropriate at this point to state explicitly that this study has been restricted in scope to an examination of some aspects of the demand for water in the Muskingum Watershed Conservancy District. The weaknesses of such a partial approach are recognized. A complete study of water in the District would, of course, entail the consideration of both demand and supply, and the recognition of the significances of the reciprocal relationships between them. It is highly

[1] I wish to express my sincere thanks and appreciation to Robert D. Teeters, presently with the Bureau of the Budget in Washington, D.C. Mr. Teeters accompanied me on all my field trips, and at various stages of this study I benefited from his constructive criticism. I also wish to thank the very many people who helped me during various stages of this study, especially Professor Lyle E. Craine, Department of Conservation, University of Michigan, Professor Gilbert F. White, University of Chicago, Professor J. Beyer, Montana State University, Mr. W. Papier, Director, Division of Research and Statistics, Bureau of Unemployment Compensation, Columbus, Mr. S. L. Frost and Mr. A. R. Rudnick, Ohio Division of Water, Columbus, Mr. Bryce Browning, executive secretary, Muskingum Conservancy District, and Professor W. L. Garrison and Mr. M. F. Dacey, University of Washington.

[2] State of Ohio, Department of Natural Resources, Division of Water, *The Conservancy Act of Ohio*, p. 8.

[3] See Morgan D. Thomas, "A Regional Model for Projecting Industrial Water Consumption," *Papers of the Michigan Academy of Science, Arts, and Letters*, Vol. XLIII, 1958 (1957 meeting), pp. 252–54. A review of the available literature on industrial water supply is forthcoming in the *Geographical Review* by Gilbert F. White.

desirable, therefore, to carry out demand and supply studies simultaneously. However, a severe limitation on the number of research workers, finances, and time did not permit the execution of such a comprehensive study. Neither was it possible to make a study of how quantities of water used changed in response to changes in the price of water to the various sectors of the economy. The author is also well aware that the use of more sophisticated techniques would have been desirable for making estimates of water use had he the necessary resources available for such an elaborate study. For example, input–output models using fixed or variable water use coefficients, different demand schedules, and population projections based on cohort survival techniques, could have been constructed. On the other extreme, straight line projections could have been made to obtain water-use patterns for 1975. The methods of this study lie between those used where research resources are unlimited and an "all out" study is possible and those used where a quick "educated guess" must be quickly made. It illustrates work with modest resources, a situation common to so many research efforts.

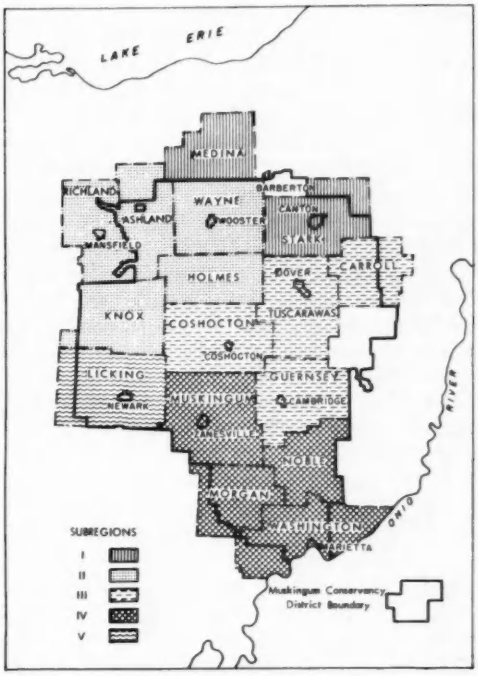


FIG. 1. The Muskingum Watershed Conservancy District, Ohio.

METHODOLOGY

The area under study (Fig. 1) is the watershed of the Muskingum River in Ohio. It is made up of the city of Barberton and the counties of Medina, Stark, Wayne, Ashland, Richland, Knox, Holmes, Tuscarawas, Carroll, Coshocton, Guernsey, Licking, Muskingum, Morgan, Noble, and Washington. The watershed of the Muskingum River does not coincide perfectly with the area chosen, for topographical watershed boundaries are not the determinants of county boundaries. Because many of the statistical data used are provided on a county basis, it was necessary to delimit the area by using county boundaries. There is a good correlation between the area delimited for study and that defined by the topographical watershed of the Muskingum River. The greatest areal discrepancies exist in the eastern part of Stark County, which includes the town of Alliance, and the northern half of Medina County. It is felt that their inclusion in the analysis does not materially affect the end product of the study. However, the inclusion of one manufacturing firm in Washington County, which obtains its water from the Ohio River, does significantly affect the results of estimating the amount of water used and *obtained from* the watershed of the Muskingum. But from the general research point of view, the inclusion of this firm is valuable because it will provide some indication of the water-using characteristics of this type of firm. The effects of both including and excluding this firm are shown in Table 13.

Many problems were encountered in choosing a method of estimating future water use by manufacturing industry. It was assumed that there is a tendency for water consumption to move in the same direction as the change in the size of industries or plants. There are, however, difficulties in choosing criteria to indicate changes in size. Two possible criteria were physical output and value of output, but it was not possible to obtain published information for these on a county basis. Furthermore, their possible use may be questioned respectively on the grounds of lack of continuous homogeneity of product and the difficulty of allowing for changes in the value of money

over time. The use of employment as a criterion also has its weaknesses. These include the partial concealment of changes in size by the substitution of capital for labor. Furthermore, changes in employment are not necessarily accompanied by proportional changes in the same direction in prime water consumption.[4] Factors such as changes in labor productivity and the application of water conservation practices modify the relationship between changes in employment and water use. These factors consequently will affect the accuracy of future water-use coefficients based on estimates of future employment levels. An attempt is made later in this paper to give some consideration to these aspects in calculating water-use patterns in the Muskingum region for 1975.

Since published employment data were available on a county basis these data primarily were used to indicate changes in the size of manufacturing industry. Consequently employment indices have been used chiefly to estimate water use in the various manufacturing industries in 1975.

There is a lack of information on water use by "other non-manufacturing" industries, and certain types of data on non-manufacturing industry and domestic water use by municipalities are not available. For this reason the two categories of non-manufacturing industry and domestic water use are combined in this paper in the calculation of an index of water use on a per capita basis. It was, however, possible to break this new category down to urban and non-urban components. The non-urban category includes villages of under-2,500 population with their own public water systems as well as dispersed rural settlements. There is reason to believe that water use per capita tends to be higher in nucleated settlements with public water systems than in dispersed rural homes relying on their own wells. Nevertheless, it is felt that such differences will not materially affect the results of this study which are meant to be only approximate.

Having delimited the area for study and chosen the kind of indices to be used in estimating water use, the next step was to examine the size, structure, and distribution of economic activity in the region. The general distribution of the population follows the distribution pattern of economic activities. A concentration of the study on manufacturing was made because of the heavy specialization in manufacturing in the region (39 percent of the total working population as compared with 26 percent for the United States as a whole), and the feeling that manufacturing was the largest user of water. Conclusions reached in the report on water use by the Conservation Foundation and National Association of Manufacturers[5] and information given by the Ohio Division of Water[6] support this approach. Employment levels in non-manufacturing activities showed a marked correlation with those in manufacturing as a whole. This is not surprising since there is such a heavy specialization in manufacturing. Furthermore, field work showed that only a very small part of the total production of manufacturing industry is sold in the region. In other words, the major part of manufacturing is basic in nature, and one tends to expect that non-basic industries which make up the greater part of the other economic activities would be sensitive to the fortunes of the basic industries.

The 1950 census provided the best complete indication of the size, structure, and distribution of *all* economic activities within the region. It was possible, however, to obtain a fine breakdown on a four-digit[7] basis for manufacturing in all the counties studied as well as for the city of Barberton. This information was obtained from the *Directory of Ohio Manufacturers* (1956),[8] which provided employment data for all firms in 1955. Employment for each firm was added and classified according to the Standard Industrial Classification List.

The region was broken down into five subregions so as to make the study more useful

[4] "Prime water" refers to the initial intake of water into a plant.

[5] *Water In Industry* (New York, 1950).

[6] Personal information obtained from S. L. Frost and A. R. Rudnick of the Ohio Division of Water.

[7] The Standard Industrial Classification List classifies all economic activities into various categories or industrial groups which are given digits to indicate the nature and degree of their aggregation. For example, primary metal industries are 33, or a two-digit group; while iron and steel foundries are 332, or a three-digit group. On the other hand, grey iron foundries are 3321, or a four-digit group.

[8] State of Ohio, Department of Industrial Relations, *Directory of Ohio Manufacturers* (Columbus, 1956).

for the Muskingum Watershed Conservancy District. It is interesting to know how much water is used in the whole region, but from the policy-making standpoint, it is much more useful to obtain an idea of the magnitude of water use in its various parts. For example, if the northeastern portion has a water shortage it is rather meaningless to say that the region as a whole has an adequate water supply.

It would also be helpful to be able to indicate the water use and supply position in adjoining sub-watersheds of the Muskingum. Present engineering costs of tapping water supplies in the vicinities of the centers of use have to be taken into account. Canton, because it is a relatively large city, can afford to supplement its present water supplies by going 16 miles southwest of the city into another sub-watershed, that of Sugar Creek. Wooster, a smaller town which needs additional water supplies, is planning to obtain supplemental water from an area 5 to 6 miles southwest of the town. At present each town thinks in terms of its own local problem and of providing its own solution. When, and if, water authorities in towns and cities begin to think of providing and distributing water on a larger areal or regional scale, then one may be required and able to analyze water use and supply aspects on a larger areal basis. Ideally, this study should have been broken down to study the water-use patterns of each town and city in the region. This was not possible because of the lack of time and money, and the necessary staff.

It must be remembered also that water is usually re-used many, many times downstream. Pollution, among other factors, influences the number of times water can be re-used. Of course, the kind of use made of the water will condition the significance of the pollution problem. Nevertheless, it is more desirable and realistic to examine water use and supply subregionally than in the region as a whole. Although this study is concerned primarily with the amounts of water used, it is hoped that a rough survey of the water supply position can be made to give greater meaning to the study. Consequently, an attempt was made to consider water use and supply on a subregional basis, and the Muskingum region was divided into the following subregions:

Subregion I—Medina and Stark counties and the city of Barberton
Subregion II—Wayne, Ashland, Richland, Knox and Holmes counties
Subregion III—Tuscarawas, Carroll, Coshocton and Guernsey counties
Subregion IV—Muskingum, Morgan, Noble and Washington counties
Subregion V—Licking County.

The combination of counties which make up the various subregions was arbitrary. It was based partly on the use of suitable subdrainage basins, especially those in the headwaters of the Muskingum River, which provided convenient sources of water supply to the main industrial centers—usually one in each county. There was also a considerable subjective element in the choice of the combinations of counties. Impressions gained from field work throughout the region and from an analysis of the questionnaires used contributed to the decision. For example, subregions I and II seemed to be pervaded by the the feeling that they were going to benefit to a great extent from the opening of the St. Lawrence Seaway. They had much in common in the type of industry in which they specialized, but the area covered by all the counties sharing these common traits was too large to be treated as one subregion. It was also felt that this study would be more useful if the area were treated as two subregions. Licking County tended to look to the national automobile industry and the prosperity of the country as a whole for its industrial stimulus. One felt it belonged more to the economy of the Columbus area than to that of the rest of the Muskingum region. People in subregion IV felt that the area was going to benefit from the great industrial developments taking place in the Ohio valley. There was a desire to benefit, but there was also a desire to be selective about the type of new industries wanted in the subregion. Aesthetic considerations influenced this thinking. One also suspects that a reluctance to share in the growth of heavy industry was partly influenced by the fear of a disruption of the existing lower wage structure in the subregion. This disruption is already taking place in Marietta. Subregion III gave the impression of being an area apart from the rest of the region. It did not seem to be stimulated by an anticipation of direct benefits

from what was going on along the Ohio valley, or what might result from the opening of the St. Lawrence Seaway. Dynamic small industrial centers like Cambridge and Coshocton seemed to draw their stimulus, as did Newark in Licking County, more from a faith in a continued economic growth of the United States as a whole. Some counties, such as Holmes, Carroll and Noble, deviated considerably from the general economic patterns of the subregions in which they were arbitrarily placed.

It was felt that in a pilot study of this kind one could not use as fine an areal breakdown as one would wish to make. One also wishes that more objective methods could have been used to delimit the subregions. This is an aspect which needs further development. However, it is hoped that the reader now has at least some indication of a few of the subjective elements which contributed to the delineation of the subregions.

After the delineation of the subregions, the next step was to examine industrial trends. The manufacturing industries were analyzed on a four-digit industry basis in each county. The purpose of this analysis was to obtain guidance on possible trends which would help to estimate employment in these industries in different parts of the region in 1975.

Unfortunately, it was not possible to obtain a detailed breakdown of manufacturing industry in the region before 1948, when the first suitable *Directory of Ohio Manufacturers* was published. In the time available, it was not possible to obtain complete coverage for all manufacturing industries in the region for more than two years. Because the author thought 1948 and 1955 were the most suitable years,[9] representing the kind of average economic conditions *expected* for the region in the next twenty years, manufacturing industry was examined in these two years on a four-digit basis.

ESTIMATES OF EMPLOYMENT IN MANUFACTURING

It was necessary to estimate employment in manufacturing industries in 1975. This was done by first estimating total employment in manufacturing for the whole region, then for the subregions. Later manufacturing was broken down on a two-digit basis for the region, then by subregions. Where it was necessary to obtain a three-digit and four-digit breakdown because of the significance of the water-using characteristics of various industries, this was done.

Two series of employment estimates were made for the region and subregions, discussed below under Method I and Method II.

Method I

The first series of employment estimates were made by using employment data obtained for 1948 and 1955. It was realized that this was far from satisfactory as it would have been desirable to have a much longer time span, and data for many more intervening years. The projections were, however, modified on the basis of information obtained at each of the following stages of analysis: (1) National and state trends of industries found in the region were examined so as to obtain an idea of the rate and direction of changes that might be expected, assuming a similarity between trends in the region, the state, and the nation. (2) Considerable emphasis was given to information obtained during the course of field work on the future plans of entrepreneurs. It was found that quite often when projections of industrial trends were disaggregated on a regional or subregional basis, these trends were in need of revision in the light of information received in the field in 1957. The projections were based, as was mentioned earlier, on published data obtained for 1948 and 1955. Between 1955 and 1957 there were many industrial developments which led to expansions in employment in various parts of the region. New employment opportunities were created, for example, by the building of a large automotive plant at Mansfield, a steel mill near Coshocton, a metals alloy plant near Beverly. Many of these new developments were not anticipated in the projections, and because they certainly were significant they necessitated modifications in the projections. (3) Similarly, during interviews with members of the management of the various firms visited, questions were asked about short-term and long-term plans. Weight was

[9] Suitable data were available only for the years 1948 to 1955, and economic conditions in 1948 and 1955 were less influenced by recession or war effort than the other years in the period.

given to their answers when it was thought that such plans would probably be implemented, and if they had not already been anticipated in the projections. (4) In considering industrial trends, judgments were also made with reference to the suitability of the region and subregions as locations for new plants. For this purpose, the total number employed in the various industries was compared with the total number employed in the same industry in the United States. In other words, if e_i = regional or subregional industry employment, and e_t = total regional or subregional employment in manufacturing, and E_i = national industry employment and E_t = national total employment in manufacturing, then

$$\frac{\frac{e_i}{e_t}}{\frac{E_i}{E_t}}$$

is the *Index of regional or subregional specialization in industry* e_i. This procedure was carried out for all manufacturing industries in the region and subregions, providing indices of regional specialization for all the industries.[10] Information obtained from such an analysis provided some idea as to the area's favorability for each of the industries at present located there. (5) The final modifications, made where necessary, to the original projections were based on the writer's knowledge on locational matters. This background was especially drawn upon when evaluating the region and subregions as locations for industries which are not found there at present.

At each stage an estimate was made of the positive or negative effects on future employment in the industry considered. These estimates were then summed, and added to or subtracted from the projected employment for that industry. The figure obtained in this manner was the estimated employment. All the estimates for the individual industries were added to give the estimated total employment in manufacturing for 1975. This total was almost 199,000.

By using a 1948 and 1955 two-point projection on semilog paper, manufacturing in the region was predicted to employ 184,000 workers in 1975. This figure was felt to be somewhat low,[11] and on the basis of judgments made as a result of the steps outlined above, it was decided to use an estimate of 199,000. This figure was checked by projecting employment in manufacturing in Ohio for 1975 by using the Askovitz graphical least squares method on semilog paper.[12] For this purpose, employment in manufacturing in Ohio[13] from 1947 to 1955 inclusive was used and a trend line was projected to 1975. Using the same statistical source, total employment in manufacturing for all the counties in the region was added, and calculated as a ratio of employment in total Ohio manufacturing for the years 1947 to 1955. These ratios were then projected by the Askovitz method on semilog paper to 1975. In this way, employment in the region in 1975 was calculated to be 10.7 percent of the Ohio total of 1,870,000, which is 200,090 persons. However, an estimated 12,000 employees must be added to this figure because employment in Barberton's industries was not given sep-

[10] The Standard Industrial Classification List was used to classify the industries. I thus assumed homogeneous product groupings. The calculation of the index of regional specialization for any industry is an employment index, and it is further assumed to be the same as one calculated on the basis of "value added," or production by the same industry. Where the region or subregion has a higher proportion of its labor force engaged in manufacturing in a particular industry than the national average for the same industry, I assume that the region or subregion specializes in that industry. Furthermore, the region or subregion is an above-average favorable location for that industry. By checking the industry's growth trends in the area under study against national trends, one may decide whether the area is becoming a more or less favorable location for that industry.

[11] Economic conditions were considered to be a little too good in 1948 to permit it to be used as a starting point for a projection showing the average trend for the period 1948–1955 and extended to 1975. Other years for which data are available are less suitable than 1948.

[12] S. I. Askovitz, "A Short-cut Graphic Method for Fitting the Best Straight Line to a Series of Points According to the Criterion of Least Squares," *Journal of the American Statistical Association*, March, 1957, pp. 13–17.

[13] State of Ohio, Department of Industrial Relations, *Directory of Ohio Manufacturers* (Columbus, 1948, 1952, and 1956).

For the years 1949, 1950, 1951, and 1953, the following sources were used: U.S. Department of Commerce, Bureau of the Census, *Annual Survey of Manufactures*, 1951, 1953.

For 1947 and 1954 the following source was used: U.S. Department of Commerce, Bureau of the Census, *Ohio 1954 Census of Manufactures*, Bulletin MC-134 (Washington, D.C., 1957), pp. 133–4.

arately in these statistical sources. This estimate was considered a little high,[14] and it was felt that the 199,000 figure, being in between the 184,000 projection and 212,000 calculated estimate, was a fairly reasonable figure to use as the region's employment in manufacturing in 1975. This total of 199,000 was then broken down and allocated to the various industrial groups in the five subregions by using information based on national, state, regional, and subregional trends and field work.

Method II

The second series of employment estimates for manufacturing industries in the region and subregions were prepared using less subjective methods. First, the total manufacturing employment was compiled for the region and subregions for the years 1947 to 1955 inclusive.[15] Trend lines were then obtained in each case by using the Askovitz least squares method and projections were made for 1975. It was assumed that in the structure of manufacturing the region resembled more the state of Ohio than the United States. Consequently, the structure of manufacturing in Ohio was used as a control for the region and subregions. The data on total manufacturing and the various two-digit manufacturing industries in Ohio[16] from 1947 to 1955 inclusive were used to project employment to 1975. (All projections in this study were made by using the Askovitz graphical least squares method on semilog paper unless otherwise stated.) The direction and magnitude of changes in employment between 1955 and the projected levels in 1975 were then obtained for total manufacturing and for the two-digit manufacturing industries. It was assumed that projected changes for the state would apply to the Muskingum region and its subregions. By using Method II it was estimated that there would be 208,000 persons employed in manufacturing in the whole region in 1975.

[14] It was thought that the influence of the Korean War tended to inflate the projections.

[15] State of Ohio, Bureau of Unemployment Compensation, Division of Research and Statistics, *Average Number of Workers Covered Under Ohio Unemployment Compensation Law by Industrial Division and County* (Columbus, for the years 1947 to 1955).

[16] *Directory of Ohio Manufacturers* and *Ohio 1954 Census of Manufactures*, pp. 133–4.

POPULATION ESTIMATES

The next step taken was to obtain estimates of the total population in the region and subregions in 1975. These estimates were necessary so that total water use could be calculated. Information was available on domestic and non-manufacturing industry water use. It was hoped that such information could be broken down to give water use separately for domestic and non-manufacturing industries. As there was no other alternative, it was decided to use total population as the basis for calculating water use other than by manufacturing industry.

An attempt was made to find a reasonably simple method of projecting population because the staff was not available to make complicated projections using age, sex ratios, and other demographic techniques. First, population was projected using decennial census data compiled on a county basis from 1910 to 1950 and using an estimate for 1956.[17] By this method total population was expected to be 1,170,000 in 1975. This was thought to be too low, judging by the rate of growth between 1940 and 1950 and expected rates of growth in the next twenty years.

Another method was then used. There had been a very stable relationship between the total U.S. population and that of Ohio since 1910. The Ohio total varied between 5.3 and 5.4 percent of the total U.S. population in this period. Ohio population was calculated at 11,961,000 in 1975 by using a recent forecast of U.S. population in 1975 of 221.5 million,[18] and the Ohio ratio of 5.4 percent. The region's population was then calculated as a ratio of Ohio's population for the decennial years since 1910. These relationships also proved to be fairly stable. A trend line of these ratios was projected to 1975. In that year, the region's population was expected to be 10.7 percent of Ohio's population of 11,961,000. Thus, according to this method, the region is expected to have a population of

[17] State of Ohio, Department of Liquor Control, *1956 Population Estimates for Ohio Counties, Cities, and Villages* (Columbus, 1956).

[18] U.S. Department of Commerce, Bureau of the Census, "Revised Projections of the Population of the United States, by Age and Sex: 1960 to 1975," *Current Population Reports, Series* P-25, No. 123 (Washington, D.C., 1955), p. 2.

1,280,000 in 1975. This figure was used in the present study.

The same kind of procedure was carried out for the subregions. Ratios were established between the population of the subregions and that of the region since 1910. The 1975 ratios were then projected and used to calculate the populations of the subregions in 1975 (see Table 1).

TABLE 1.—PROJECTED POPULATION FOR THE MUSKINGUM REGION AND SUBREGIONS IN 1975

Area	Population	
	Percent	Total
Subregion 1	43.48	556,600
Subregion 2	23.71	303,400
Subregion 3	14.21	181,900
Subregion 4	11.37	145,500
Subregion 5	7.23	92,600
Muskingum Region	100.00	1,280,000

ESTIMATES OF WATER USE IN MANUFACTURING

To calculate water-use coefficients or indices, water-use data were obtained from a sample survey in the Muskingum region. This information was supplemented by data obtained from the Ohio Division of Water, and in a few cases from letters written to individual plants. In the field survey a random sample,[19] stratified by employment, was used. It covered all plants employing over one thousand workers, and one-third of the plants employing between 250 and 999 workers. One in every sixty-seven plants which employed 249 or fewer workers were also included. All the plants visited accounted for a little over 52 percent of the total employed in manufacturing in the region. Table 2 shows that the sample provided good coverage for the heavy water-using industries, such as primary metals, rubber, chemical and mechanical engineering.

Data on the amount of water used for power generation were obtained from Mr. B. D. Eley, of the Ohio Power Company office at Canton, personal visits to generating plants, and by correspondence.

[19] The sample was drawn in consultation with Professor Leslie Kish, Survey Research Center, University of Michigan.

Water-use indices for manufacturing industries were calculated by dividing the average yearly employment into the amount of water used over the year. This was done for all two-digit industries in the region and subregions. For heavy water-using industries a finer industrial breakdown was used.[20] Four-digit industries of this kind were grouped to form separate parts of the two-digit industries to which they belonged. In this way it was possible to provide the 1955 water-use pattern for manufacturing industry.

Two series of water-use estimates for manufacturing in 1975 were prepared. Two estimates for each series were made, using some data obtained by different methods, and also different assumptions in a few cases.

First Series of Water-Use Estimates

In the first series of water-use estimates the employment estimates for 1975 obtained by Method I were used. It was assumed that water use per employee would not change between 1955 and 1975. The 1955 water-use index was then multiplied by the relevant 1975 employment estimates to give the estimated yearly water use for that industry in 1975. These calculations were made for the region and subregions.

An alternative set of water-use estimates also made in the first series were calculated. In this case, an attempt was made to relate changes in water use to changes in output. Labor productivity estimates for the nation calculated from Federal Reserve Board and Bureau of Labor Statistics data were used in preparing these estimates.[21] Productivity indices for the various manufacturing industries for the years 1947 and 1955 were used for making linear projections of labor productivity coefficients for 1975. In other words, the increase in production for each industry between 1947 and 1955 was multiplied by two and a half[22] to give the increase or decrease

[20] The chemical industry was not broken down because it was dominated by one plant.

[21] U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States 1956* (Washington, 1956), p. 792.

U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Payrolls*, Annual Supplement Issue (Washington, April, 1952, and June, 1956).

[22] 1947–1955 = 8 year period; 1955–1975 = 20 year period; 1955–1975 = 2½ times the period between 1947 and 1955.

in output expected between 1955 and 1975. This increase or decrease in output was then weighted to the increase or decrease in employment expected for that industry between 1955 and 1975, and the labor productivity coefficient calculated. For example:

Industry *A*. Output in 1947 = 100. Output in 1955 = 120

Linear projected output in 1975 with 1955 = 100 =20 × 2½ = 50+ 100 = 150

Employment in Industry *A* in 1955 = 100; For 1975, employment is estimated at 125

Labor productivity coefficient for 1975 = $\frac{150}{125} = 120$

Water use in Industry *A* in 1975 = water-use coefficient in 1955 × employment in 1975 × 1.2

In this method it is assumed that the amount of water used per unit of output will remain constant until 1975, and that labor productivity is the same in the region and subregions as that for the U.S.

Second Series of Water-Use Estimates

In the second series of water-use estimates, the water-use patterns of manufacturing industries in 1975 are obtained in two ways. Both of the methods use employment projections for 1975 obtained by Method II, outlined earlier in this paper. In the first method of the second series of water-use estimates, water-use indices for 1975 were calculated for the various industries in the region.

As water-use indices were based on the quantity of water used per worker, it was felt that an attempt should be made to evaluate the effects of anticipated increases in output per employee and the wider adoption of water conservation practices between 1955 and 1975. Increased output per employee would tend to lead to a greater use of water per employee, whereas the greater application of water conservation practices would lead to the use of less water per employee. Complete information on these opposing trends is not available. While doing field work an attempt was made to get some idea of changes in productivity over time, and to obtain information on the possible application of water conservation measures. In the majority of plants visited detailed information was either lacking, or the entrepreneurs did not want to reveal the information. The writer felt that the relevant data were unavailable mainly for the former reason.

Allowances for the effects of changes in labor productivity and water conservation

TABLE 2.—EMPLOYMENT IN SAMPLE OF PLANTS VISITED IN THE MUSKINGUM REGION IN 1957

Industry group number	Industry group	Employment in sample plants				Employment in region	
		Over 1000 workers	250–999 workers	1–249 workers	Total	Total number	Percent in sample
20	Food and kindred products		462	63	525	7,031	7.47
22	Textile mill products					399	—
23	Apparel					1,216	—
24	Lumber and wood products			92	92	1,789	5.14
25	Furniture and fixtures	2,038	403		2,441	3,731	65.42
26	Paper and allied products	1,773			1,773	4,594	38.59
27	Printing, publishing and allied industries		1,093	5	1,098	4,516	24.25
28	Chemicals and allied products	1,962		39	2,001	3,513	56.96
29	Products of petroleum and coal			168	168	628	26.75
30	Rubber products	4,563	2,117		6,680	11,311	59.06
31	Leather goods					36	—
32	Stone, clay and glass products	6,231	1,276	109	7,616	21,019	36.23
33	Primary metal industries	17,376	1,193	3	18,572	30,638	60.61
34	Fabricated metal goods	5,817	2,533		8,350	18,277	45.69
35	Non-electrical machinery	19,009	2,450	15	21,474	29,599	72.55
36	Electrical machinery	6,966	2,129		9,095	14,923	60.95
37	Transportation equipment	1,689	695		2,384	3,437	69.36
38	Professional, scientific and controlling instruments					811	—
39	Miscellaneous	1,594	589	132	2,315	4,355	53.16
	Total	69,018	14,940	626	84,584	161,823	
	Percent of total in region	42.65	9.23	0.38	52.26	100.00	52.26

TABLE 3.—SERIES I ESTIMATES OF WATER USE IN SUBREGION I FOR 1975, IN MILLION GALLONS A YEAR

Industrial group[1]	Water use 1955	1955 Water-use coefficient	Method I		Method II	
			Estimated employment in 1975	Water use 1975	Labor productivity index 1975	Water use 1975
20	903	0.257	3,950	1,015	1.18	1,198
22	9	0.279	50	14	2.17	30
23	—	—	690		1.20	—
24	3	0.008	1,000	8	2.32	19
25	118	0.046	3,800	175	1.24	217
26	134	0.197	1,620	319	1.57	501
27	23	0.017	3,850	66	1.32	87
28	14,774	6.03	1,900	11,457	1.94	22,227
29	286	1.25	980	1,225	1.72	2,107
30a	987	0.503	1,800	905	1.85	1,674
30b	564	0.172	4,500	774	1.85	1,432
32a	—	—	—		1.82	—
32b	20	0.093	250	23	1.82	42
32c	71	0.024	2,640	63	1.82	115
32d	40	1.57	35	55	1.82	100
32e	290	1.60	275	440	1.82	800
33ab	21,071	1.686	8,000	13,488	1.74	23,469
33c	483	0.141	3,490	492	1.74	856
33d	4	0.174	300	52	1.74	90
33e	30	0.062	350	22	1.74	38
33f	1,006	0.206	4,860	1,001	1.74	1,742
34a	5	0.002	305	1	1.38	1
34b	350	0.052	5,715	297	1.38	410
34c	444	0.119	3,980	474	1.38	654
35a	40	0.023	1,500	35	2.10	73
35b	52	0.009	1,135	10	2.10	21
35c	44	0.017	4,150	71	2.10	149
35d	190	0.067	4,045	271	2.10	569
35e	674	0.271	2,070	561	2.10	1,178
35f	2,871	0.247	11,100	2,741	2.10	5,756
36a	22	0.009	4,000	36	1.59	57
36b	5	0.031	700	22	1.59	35
37	—	—	200	—	1.74	—
38	13	0.055	400	22	1.45	32
39	249	0.105	2,400	252	1.80	454
Total	45,775	0.562	86,050	36,387	1.82	66,203

[1] The following descriptions of industrial subgroups are applicable for Tables 3 to 8: Four digit numbers of industries included are given in parentheses:

30a—Tires and inner tubes and reclaimed rubber (3011, 3031).
30b—Rubber industries, not elsewhere classified (3099).
32a—Glass products (3211–3231).
32b—Cement, hydraulic (3241).
32c—Clay and pottery products (3251–3269).
32d—Other non-metallic mineral products (3271–3298).
33a—Blast furnaces, steel works, and rolling mills (3311, 3312).
33b—Electrometallurgical products (3313).
33c—Iron and steel foundries (3321–3323).
33d—Non-ferrous metal refining, drawing and rolling (3331–3359).
33e—Non-ferrous foundries (3361).
33f—Miscellaneous primary metal industries (3391–3399).
34a—Hardware (3411–3429).
34b—Plumbing and sheet metal products (3431–3444).
34c—Miscellaneous fabricated metal products (3461–3499).
35a—Engines and turbines (3511, 3519).
35b—Farm and other machinery (3521–3532).
35c—Machine tools (3541–3543).
35d—Industrial machinery (3551–3569).
35e—Store and household machines (3571–3589).
35f—Valves, bearings and miscellaneous machinery (3591–3599).
36a—Electrical motors and industrial machinery (3611–3619).
36b—Electrical appliances and related products (3621–3699).

TABLE 4.—SERIES I ESTIMATES OF WATER USE IN SUBREGION II FOR 1975, IN MILLION GALLONS A YEAR

Industrial group	Water use 1955	1955 Water-use coefficient	Method I		Method II	
			Estimated employment in 1975	Water use 1975	Labor productivity index 1975	Water use 1975
20	456	0.291	1,650	480	1.18	566
22	2	0.105	50	5	2.17	11
23	4	0.013	400	5	1.20	6
24	10	0.023	450	10	2.32	23
25	97	0.191	700	134	1.24	166
26	1,314	0.502	2,510	1,260	1.57	1,978
27	33	0.020	2,750	55	1.32	73
28	468	0.954	400	382	1.94	741
29	—	—	20	—	—	—
30a	549	0.209	3,600	752	1.85	1,391
30b	191	0.083	4,400	365	1.85	675
32a	57	0.045	1,210	55	1.82	100
32b	—	—	—	—	1.82	—
32c	28	0.053	390	21	1.82	38
32de	131	0.341	600	205	1.82	373
33ab	5,739	2.383	2,600	6,195	1.74	10,779
33c	28	0.031	1,060	33	1.74	57
33d	—	—	—	—	—	—
33e	9	0.026	340	9	1.74	16
33f	—	—	—			—
34a	19	0.076	280	21	1.38	29
34b	186	0.061	3,940	240	1.38	331
34c	506	0.677	780	528	1.38	729
35a	104	0.072	1,600	115	2.10	159
35b	3	0.024	200	5	2.10	11
35c	4	0.024	245	6	2.10	13
35d	50	0.033	1,650	54	2.10	113
35e	—	—	—			—
35f	283	0.235	760	179	2.10	376
36a	118	0.015	6,945	104	1.59	165
36b	83	0.273	555	152	1.59	242
37	12	0.007	5,300	37	1.74	64
38	20	0.036	1,800	65	1.45	94
39	1	0.005	300	2	1.80	4
Total	10,513	0.283	47,500	11,474	1.68	19,344

practices were made in the following manner. Some information on the influences of these factors and broad trends was obtained from a cursory survey of literature dealing with the national scene and a few individual industries. A little information was also obtained from a few of the firms visited. On the basis of this information the writer attributed percentage changes in the use of water as a result of expected changes in productivity and in water conservation practices for each industry. These percentage figures were shown to a number of economists and water-use specialists, and on the basis of discussions which followed, the percentages were usually modified. The resultant percentages were then added to or subtracted from the relevant original calculated water-use index.

In the second method in the second series of water-use estimates, the calculation of water-use indices involved the calculation of labor productivity coefficients, again using employment figures obtained from Method II, above. Tables 3 to 9 inclusive give the water-use estimates for both methods in Series I and Series II. However, only in Series I are the two methods used for the region and subregions. In the second series, because of the shortage of staff, the two methods are applied only to the region as a whole.[23]

[23] To calculate water use in the subregions for Series II, and using employment estimates obtained by Method II, one simply obtains the relevant 1955

TABLE 5.—SERIES I ESTIMATES OF WATER USE IN SUBREGION III IN 1975, IN MILLION GALLONS A YEAR

Industrial group	Water use 1955	1955 Water-use coefficient	Method I		Method II	
			Estimated employment in 1975	Water use 1975	Labor productivity index 1975	Water use 1975
20	346	0.458	750	344	1.18	406
22	2	0.017	30	1	2.17	2
23	18	0.035	650	23	1.20	28
24	1	0.005	50	—	2.32	—
25	2	0.016	—	—	1.24	—
26	383	0.613	600	368	1.57	578
27	12	0.015	1,720	26	1.32	34
28	160	0.798	1,400	1,174[1]	1.94	2,277
29	—	—	—	—	1.72	—
30a	—	—	—	—	1.85	—
30b	72	0.160	700	112	1.85	207
32a	150	0.643	70	45	1.82	82
32b	—	—	—	—		—
32c	123	0.040	2,760	110	1.82	200
32d	60	0.031	1,135	35	1.82	64
32e	1	0.013	35	1	1.82	2
33ab	5	2.036	3,250	6,617[1]	1.74	11,513
33c	130	0.202	500	101	1.74	176
33d	25	0.125	250	31	1.74	54
33e	33	0.098	200	20	1.74	35
33f	172	0.538	400	215	1.74	374
34a	391	0.538	500	269	1.38	371
34b	574	0.496	1,360	675	1.38	932
34c	134	0.125	1,140	143	1.38	197
35a	—		—		2.10	—
35b	34	0.032	1,454	47	2.10	99
35c	—	—	—		2.10	—
35d	19	0.739	110	81	2.10	170
35ef	69	0.300	436	131	2.10	275
36a	—	—	80	—	1.59	—
36b	65	0.058	2,420	140	1.59	223
37	—	—	—		1.74	—
38	—	—	—		1.45	—
39	14	0.098	2,000	196	1.80	353
Total	2,926	0.159	24,000	10,905	1.71	18,672

[1] Reflects existing plans for plants being built.

NON-MANUFACTURING WATER-USE ESTIMATES

Water used by non-manufacturing activities and the general population was estimated for 1975 in the following manner. Information on water use in all cities, towns, and villages with public water systems was obtained by personal interview and from the Ohio Department of Health.[24]

The population of these cities, towns, and villages was obtained from 1956 population estimates prepared for the Ohio Liquor Control Board. It was possible from these sources to calculate two indices, one for the non-manufacturing uses in communities having 2,500 people or more, and the other for communities having 2,499 people or less, but with public water systems. For both, water use was calcu-

water-use coefficient from Series I water-use tables. This coefficient is multiplied by the relevant employment estimate obtained from tables made by Method II. The product is then multiplied by the "subjective water-use index" for 1975 for that particular industrial group given in the Series II water-use table for the whole region—Table 9.

[24] *Meter Rates, Meter Installations and Water Consumption for Ohio Municipalities* (Columbus, 1954); *Incorporated Municipalities in Ohio with Water Works* (Columbus, 1956).

TABLE 6.—SERIES I ESTIMATES OF WATER USE IN SUBREGION IV FOR 1975, IN MILLION GALLONS A YEAR

Industrial group	Water use 1955	1955 Water-use coefficient	Method I		Method II	
			Estimated employment in 1975	Water use 1975	Labor productivity index 1975	Water use 1975
20	251	0.243	1,950	474	1.18	559
22	46	0.391	100	39	2.17	85
23	7	0.069	200	14	1.20	17
24	33	0.058	1,100	64	2.32	148
25	38	0.070	100	7	1.24	9
26	201	0.750	400	300	1.57	471
27	2	0.005	580	3	1.32	4
28	151	1.020	400	408	1.94	792
29	—	—	—	—	—	—
30a	—	—	—	—	—	—
30b	305	0.615	1,800	1,107	1.85	2,048
32a	104	0.077	1,630	126	1.82	229
32b	187	0.497	450	224	1.82	408
32cd	280	0.084	3,870	325	1.82	591
32e	10	0.023	600	14	1.82	25
33ab	18,883	5.63	3,210	18,072[1]	1.74	31,445
33c–f	5	0.052	790	41	1.74	71
34a	—	—	—	—		
34b	9	0.051	200	10	1.38	14
35a–c	8	0.014	1,430	20	2.10	42
35f	83	0.078	1,870	146	2.10	307
36a	160	0.178	1,900	338	1.59	537
36b	68	0.052	2,250	117	1.59	186
37	—	—	200	—	1.74	—
38	—	—	70	—	1.45	—
39	9	0.046	400	18	1.80	32
Total	20,840	1.227	25,500	21,867	1.74	38,060

[1] Two electrometallurgical plants are estimated to use 90 percent of all water used in Subregion IV in 1975. Both plants obtain their water from the Ohio River.

lated on a per capita basis. It was assumed that rural homes and places not having public water systems would use the same amount of water per capita as communities with public water systems and with less than 2,499 people.

The estimated populations of the region and subregions in 1975 were classified into urban (more than 2,500 people) and non-urban by calculating the proportion of total population in each. The 1910 to 1950 decennial population censuses were used to provide the necessary data. These proportions were then projected to 1975.

Per capita water-use indices for 1975 were obtained by adding yearly an extra 1.5 gallons per day for the period 1955 to 1975. In other words, it is assumed that in 1975 each person will use 30 gallons a day more than in 1955. This is a representative figure for urban communities throughout the country during the last decade.[25] The same daily increase in per capita use of water is also assumed for rural communities.

Total water use for non-manufacturing, domestic, and town and city service purposes was calculated by multiplying the per capita water-use index for the urban population by the estimated urban population in 1975. This total water used by the urban population was then added to the product of the index of per capita water use of the non-urban population multiplied by the estimated total non-urban population to give the total water used by urban and non-urban populations in the region and subregions (Table 10).

Total water use was obtained by adding the estimates of water which will be used by manufacturing industries and other non-manufacturing purposes outlined in the above

[25] W. A. Hardenbergh (ed.), "Present and Future Estimates of Water Consumption," *Public Works Magazine*, Vol. 87 (Dec., 1956), pp. 73–77.

TABLE 7.—SERIES I ESTIMATES OF WATER USE IN SUBREGION V FOR 1975, IN MILLION GALLONS A YEAR

Industrial group	Water use 1955	1955 Water-use coefficient	Method I		Method II	
			Estimated employment in 1975	Water use 1975	Labor productivity index 1975	Water use 1975
20	8	0.046	200	9	1.18	11
22	—	—	120	—	—	—
23	—	—	60	—	—	—
24	26	0.368	100	37	2.32	86
25	—	—	—	—	—	—
26	35	0.086	570	49	1.57	77
27	1	0.003	1,000	3	1.32	4
28	32	0.567	100	57	1.94	110
29	395	1.068	400	427	1.72	734
30	8	0.039	1,000	39	1.85	72
32	1,755	0.438	3,750	1,643	1.82	2,990
33	608	0.364	2,000	728	1.74	1,267
34a	2	0.018	200	4	1.38	6
34b	65	0.595	200	119	1.38	164
34c	42	0.154	400	62	1.38	86
35	4	0.019	500	10	2.10	21
36	74	0.051	2,000	102	1.59	162
37	156	0.092	3,200	294	1.74	512
39	1	0.009	200	2	1.80	4
Total	3,212	0.200	16,000	3,585	1.76	6,312

paragraph. Table 13 shows the estimates of the total amount of water which will be used in the Muskingum region and its subregions in 1975.

COMPARISON OF WATER USE AND SUPPLY IN 1975

It was decided that this study would be of greater use if it were possible to compare the estimates of water use with estimates of water supply in 1975, for these comparisons would then give the approximate relationship between use and supply in 1975.

Two series of estimates of surface water availability were calculated by Mr. Teeters from data prepared by the U.S. Geological Survey.[26] The first estimates were obtained at convenient gaging stations at the downstream end of the drainage basins in the various subregions. In some cases, two sub-drainage basins were combined to provide a drainage area approximately the size of that supplying the subregion with water. Of course, the farther down the total watershed the gaging station, the greater the drainage area, and the greater the disparity between the area of the counties making up the subregions and the area of the drainage basin supplying their surface water. For example, the counties of Stark and Medina and the city of Barberton, which make up Subregion I, cover 1,003 square miles at the upper end of the region. The water supply area of this subregion covers 1,400 square miles. The total surface water supply of this drainage area of 1,400 square miles is obtained by taking long-term mean flow readings at gauges on the Tuscarawas River above Dover, which accounts for a drainage area of 1,100 square miles. The remaining 300 square miles is accounted for by readings of long-term mean flows taken at Beech City on Sugar Creek.[27] Subregion IV, on the other hand, is at the lower end of the Muskingum watershed, and although its area is only 2,117 square miles, it is supplied at Marietta by the surface water of the total watershed, which is 8,038 square miles or almost four times as large as the subregion. By dividing the long-term mean flow given in cubic feet per second by the respective drainage areas, one obtains long-term mean flow in cubic feet per second per square mile for each subregion and the whole Muskingum region. These figures were then converted to long-

[26] "Surface Water Supply of the United States 1954," *Water Supply Paper 1335* (Washington, D.C., 1956).

[27] The city of Canton is in the process of establishing new well fields in the Sugar Creek watershed to supplement its present water supplies.

TABLE 8.—SERIES I ESTIMATES OF WATER USE IN THE MUSKINGUM REGION FOR 1957, IN MILLION GALLONS A YEAR

Industrial group	Water use 1955	1955 Water-use coefficient	Method I		Method II	
			Estimated employment in 1975	Water use 1975	Labor productivity index 1975	Water use 1975
20	1,964	0.273	8,500	2,322	1.18	2,740
22	59	0.113	350	40	2.17	87
23	29	0.024	2,000	48	1.20	57
24	73	0.042	2,700	113	2.32	262
25	255	0.069	4,600	317	1.24	393
26	2,067	0.402	5,700	2,296	1.57	3,605
27	71	0.016	9,900	158	1.32	209
28	15,585	3.209	4,200	13,478	1.94	26,147
29	681	1.080	1,400	1,512	1.72	2,601
30a	1,536	0.315	5,400	1,701	1.85	3,147
30b	1,140	0.170	12,400	2,108	1.85	3,899
32a	2,064	0.310	6,430	1,993	1.82	3,627
32b	207	0.346	700	242	1.82	440
32c	573	0.047	8,200	385	1.82	701
32de	473	0.231	4,370	1,011	1.82	1,840
33ab	45,698	2.637	17,060	44,995	1.74	78,291
33c	1,191	0.200	5,200	1,040	1.74	1,809
33d	28	0.071	3,120	222	1.74	386
33e	72	0.062	930	58	1.74	101
33f	1,183	0.252	5,290	1,334	1.74	2,321
34a	417	0.332	1,285	427	1.38	589
34b	1,182	0.113	11,415	1,290	1.38	1,780
34c	1,126	0.192	6,300	1,207	1.38	1,665
35a	144	0.045	3,300	149	2.10	313
35b	65	0.054	3,889	210	2.10	441
35c	80	0.023	4,395	101	2.10	212
35d	245	0.069	6,435	444	2.10	932
35e	693	0.028	2,150	60	2.10	126
35f	3,306	0.234	14,086	3,296	2.10	6,921
36a	374	0.032	14,925	468	1.59	744
36b	221	0.076	5,925	450	1.59	715
37	168	0.050	8,900	445	1.74	774
38	33	0.041	2,270	93	1.45	135
39	260	0.061	5,300	323	1.80	581
Total	83,263	0.515	199,050	84,218	1.76	148,591

term yearly flow in billion gallons a year, and they roughly indicate the long-period, sustained yield water supply totals for the region and subregions. Of course, these totals can be exceeded in one year by drawing on ground water reserves where available. However, in the long period the totals can be changed only by tapping fossil water and other drainage areas, or by higher mean rainfall. In addition, methods used to cut down evaporation and transpiration water losses would increase total long-term water supplies. In this study, it is assumed that the long-term yearly flows will be the same in 1975 as they were in the periods for which they were calculated (Tables 11, 12).

Another series of surface water supply estimates was made for 1954, a year of drought, with lowering ground water levels.[28] The same gaging stations were used as for the previous long period surface water supply estimates. Instead of using long-term mean flows, mean flows for the water year 1954 were used, and the total flows for that year were then calculated in billion gallons a year for the region and subregions in the same way as for the first series of surface water supply estimates. The two series of surface water supply estimates provide fairly good measuring rods to measure water use against surface water

[28] See Ohio Division of Water, *Ground-Water Levels in Ohio, 1953–54*, Bull. 29 (Columbus, 1956).

TABLE 9.—SERIES II ESTIMATES OF WATER USE IN THE MUSKINGUM REGION FOR 1957, IN MILLION GALLONS A YEAR

Industrial group	Water use 1955 (1)	1955 Water-use coefficient (2)	Estimated employment 1975 (3)	Method I: Subjective water-use index 1975 (4)	Method I: Water use 1975 (5) (columns 2×3×4)	Method II: Labor productivity index 1975 (6)	Method II: Water use 1975 (7) (columns 2×3×6)
20	1,964	0.273	7,729	1.09	2,300	1.18	2,489
23	29	0.024	716	1.11	19	1.20	21
24	73	0.042	2,552	1.60	171	2.32	249
25	255	0.069	3,891	1.20	322	1.24	333
26	2,067	0.402	5,972	1.21	2,905	1.57	394
27	71	0.016	7,109	1.25	142	1.32	150
28	15,585	3.209	4,429	1.24	17,624	1.94	27,572
29	681	1.080	1,227	1.32	1,749	1.72	2,279
30	2,676	0.236	9,603	1.36	3,082	1.85	4,193
32	3,317	0.158	31,815	1.21	6,083	1.82	9,150
33	48,172	1.572	39,673	1.18	73,589	1.74	108,517
34	2,725	0.149	22,034	1.15	3,766	1.38	4,530
35	4,533	0.153	33,983	1.35	7,017	2.10	10,919
36	595	0.040	21,741	1.33	1,157	1.59	1,383
37	168	0.050	7,923	1.27	503	1.74	689
Other	352	0.063	7,603	1.15	551	1.44	690
Total	83,263	0.514	208,000	1.13	120,980	1.76	173,558

supply in a period of low rainfall and against the supply of water available over the long period at a sustained yield basis. Table 13 shows surface water availability in the Muskingum region and subregions, as well as comparisons of the total expected water uses, and surface water supplies in 1975.

REFINEMENT OF THE MODEL

In reviewing the methods and techniques which were used to obtain estimates of water use in the Muskingum region, the following comments and suggestions seem pertinent. Too little attention has been given in the past to the study of water use by non-manufacturing industrial groups. Because of a lack of suitable data, it was not possible to calculate water-use indices for these industrial groups. The use of such indices, when available, would provide additional improvements to the model used in this study. It is possible that further refinement could be achieved by obtaining and using data on all four-digit manufacturing groups for the intervening years between 1948 and 1955. However, staff, cost, and time are three variables which have to be taken into consideration when contemplating the refinement of the model!

Estimates of employment obtained objectively were, on the whole, very similar to those obtained by using more subjective methods. Such objective estimates are more rational when the structure of manufacturing industry in the region or subregion is the same as that of the control area; in this study, Ohio was used. This presupposes, of course, that the estimates of future structural changes for Ohio are correct, and that these will also apply proportionately to the region or subregion. These assumptions are a source of weakness because the structure of manufacturing industry in the region and subregions differs from that for the state. In addition, there is little chance that future rates and direction of structural changes in Ohio will be exactly the same in the region and subregions. Under the circumstances, however, it seemed reasonable to make these assumptions.

There is a need for further work on calculating regional water-use indices. In this respect, information on the relationships between water use and changes in output and employment in different industries will be particularly valuable. The calculation of more precise water-use indices will be facilitated by data on the effects of water conservation practices. Until better data are available, it is useful to use indices based on employment

TABLE 10.—DOMESTIC AND NON-MANUFACTURING[1] WATER USE IN 1956 AND 1975 IN THE MUSKINGUM REGION AND SUBREGIONS

Subregion		1956			1975		
		Estimated population	Water use		Estimated population	Water use	
			Gpcd[2]	Mgy[3]		Gpcd[2]	Mgy[3]
I	Urban	249,146	98.7	8,978	361,722	129	17,031
	Rural	150,128	62.3	3,411	194,771	92	6,541
	Total	399,274		12,389	556,604		23,572
II	Urban	115,332	98.8	4,158	150,774	129	7,100
	Rural	150,574	62.7	3,447	152,592	93	5,180
	Total	265,906		11,763	303,427		12,280
III	Urban	75,180	123.4	3,387	75,134	153	4,194
	Rural	109,177	62.9	2,507	106,788	93	3,625
	Total	184,357		5,894	181,953		7,819
IV	Urban	64,375	100.4	2,359	73,471	130	3,488
	Rural	81,716	66.4	1,980	72,015	96	2,523
	Total	146,091		4,339	145,512		6,011
V	Urban	41,090	128.9	1,934	49,057	159	2,850
	Rural	38,740	61.9	874	43,503	92	1,461
	Total	79,830		2,808	92,575		4,311
Total	urban	545,123	104.9	20,816	710,158	135	34,663
	rural	530,335	63.4	12,219	569,669	93	19,330
	region	1,075,458		33,035	1,279,827		53,993

[1] Excluding water used for power generation.
[2] Gpcd—gallons per capita a day.
[3] Mgy—million gallons a year.

changes and labor productivity changes to give lower and upper limits for water-use estimates as provided in Tables 3 to 8. It is suggested that objective methods as obtained by using Method II should only be used when it is not possible to carry out field work, or when a detailed breakdown of industries on a four-digit basis is not possible. The methods of estimating employment and labor productivity and water use should not be used over a longer future time span than twenty to twenty-five years. Estimates over a longer time span will require considerable refinement in the projections of total population, employment, and productivity for the various industrial groups.

SUMMARY AND CONCLUSIONS

Before discussing the results of the study outlined in this report, it is necessary to state some of the general assumptions upon which the results and conclusions rest. The projections and estimates are founded on the assumption that proper trend lines have been fitted, and that the conditions which affected the data used will be the same in the future period under consideration. In other words, if causal factors change in their influence and/or nature in the next sixteen years, the estimates prepared will differ from reality to a greater or lesser extent. Their degree of error is not only dependent on future changes in the influence of causal factors, but also on the validity of the assumptions made in making the projections, and in the accuracy of the various calculations made. Trend lines and the estimates should be revised periodically as new data become available, and when new and better assumptions can be made. These estimates are guesses—at best, scientific guesses!

This study has shown the value of considering the significance of the three aspects of industry and population; namely, its size, structure, and distribution on the use of water. In subregion I, it is expected that in 1975 less water will be used by manufacturing than in 1955. Expected changes in the structure of manufacturing industry in the subregion partly explains this fall in total use, despite an increase in employment and output. Subregion I also serves to emphasize the importance of considering the size and distribution of industries and population. The subregion's location in the upper reaches of the watershed places it in an unfavorable location with regard to water supply, and the large concentration of

TABLE 11.—MUSKINGUM RIVER BASIN DATA FOR COMPUTATION OF SURFACE WATER AVAILABILITY[1]

Subregion	River	Gaging Station	Drainage area	Years of record	Mean flow (cfs)[2] Long term	Mean flow (cfs)[2] 1954 Water year
I	Tuscarawas	Above Dover	1,398	31	1,368	758
I	Sugar Creek	Beach City	300	16	261	94.7
II	Walhonding	Nellie	1,502	33	1,438	685
II	Killbuck Cr.	Killbuck	466	24	381	170
III	Muskingum	Dresden	5,982	33	6,115	2,600
IV	Muskingum	McConnellsville	7,411	33	7,236	2,881
V	Licking	Toboso	672	33	677	210

[1] From "Surface Water Supply of the United States 1954, Part 3A," *U.S. Geological Water Supply Paper 1335* (Washington, D.C., 1956).
[2] Cfs—cubic feet per second.

population and manufacturing in the subregion increases the possibility of water shortages occuring there.

Table 13 shows how comparisons of water availability and water use provide a crude but approximate method of focussing attention on subregions which may have at present, or in the near future, water shortage problems. In other words, the method provides a measuring rod to determine the priority of action required to obtain more detailed and comprehensive information about the situation, and what lines of action to take.

The study also shows that a substantial increase in the total population of the region may be expected by 1975. It is estimated that the total population will increase by more than 204,000, or 19 percent, between 1956 and 1975. When one considers that, in addition, each person will most likely use more water in 1975 than in 1956, it can be seen that there will be a considerable increase in the amount of water used in the next eighteen years. Power generation is also expected to grow in the region, adding greatly to the total amount of water used. This is mainly a non-consumptive use of water, and it does not materially affect the quality or total supply of water available for further use. It does, however, affect the temperature of the water, which can influence the suitability of the water for cooling purposes downstream of the power plant. This influence will vary with the distance between the next user and the power plant, the degree of turbulence, and the rate and volume of flow of the river, as well as the warming effects of the sun.

In the future years under consideration, it is expected that there will also be a growth in the number employed in manufacturing in the region as well as an increase in the output of each employee. These forces tend to increase the amount of water used, but allowances must also be made for the anticipated effects of the greater application of water conservation practices by 1975, which will tend to reduce the amount of water used per unit of output or per worker employed. After making these allowances, it was estimated that manufacturing industry will use approximately 33 billion gallons or 40 percent more water in 1975 than it did in 1955. This compares with an increase in the same period of 21 billion and 63.5 billion gallons, or 63 and 18 percent, respectively, for (1) domestic and non-manufacturing uses and (2) power generation. It is expected that water use in the whole region will, however, grow by 25 percent or 117.501 billion gallons between 1955 and 1975.

Total water uses are compared with the amount of water available in the region in Table 13. This table shows that the region will use over 588 billion gallons of water in 1975, but the mean supply of water available on a sustained yield basis is only 185 billion gallons, and only 73.7 billion gallons of surface water are available in a dry year like 1954. This means that in 1975 water will have to be re-used on an average of three times if it is a year of average rainfall, or about eight times in a dry year. The same table shows that subregions II, III, and V in average rainfall years have a greater supply of surface water than they use, but in a dry year like 1954, all sub-

TABLE 12.—COMPUTATION OF SURFACE WATER AVAILABILITY IN THE MUSKINGUM REGION

Sub-region	Selected watershed	Drainage area	Flow, 1954 water year		Long-term mean flow	Long-term yearly flow
			Csm[1]	Bgy[2]	Csm[1]	Bgy[2]
I	Tuscarawas River at Stark Co. line	1,398	0.542	14.1	0.978	25.4
	Sugar Creek at Beach City	300	0.315	2.2	0.870	6.1
		1,698		16.3		31.5
II	Walhonding River at Nellie	1,502	0.456	16.1	0.957	33.8
	Killbuck Creek at Holmes Co. line	466	0.364	4.3	0.817	9.6
		1,968		20.4		43.4
III	Muskingum River above Dresden	5,982	0.434	60.4	1.022	141.7
IV	Muskingum River at Marietta	8,038	0.388	73.7	0.977	185.0
V	Licking River at Toboso	672	0.312	5.0	1.007	16.1

[1] Csm—cubic feet per second per square mile.
[2] Bgy—billion gallons a year.

regions will have to re-use their supply of surface water.

The situation is most serious in subregion I, and to a lesser extent in subregion V. Although use far exceeds supply in subregion IV, it must be remembered that 90 percent of the estimated water used in 1975 will be accounted for by power plants, and a further 6.0 percent of the total 390.4 billion gallons will be obtained from the Ohio River. Water supply appears to be good in subregions II and III, except in dry years when use will exceed surface water supply.

However, the water-use and supply problem will not be as acute as Table 13 indicates. Short-period supply can be supplemented by drawing on ground water reserves. In addition, water can be, and will be re-used within the various subregions.[29] Nevertheless, there is sufficient evidence to support a recommendation that a further detailed study of water supply in subregions I and V is desirable.

Subregion I, with the large industrial city of Canton and the medium-sized city of Barberton on the northeastern rim of the Muskingum watershed, are unfavorably situated from the point of view of water supply. Heavy concentrations of population and heavy water-using industries render the subregion especially sensitive to the adequacy of water supply. Field work showed that a great number of large plants which were also heavy users of water had experienced water shortages in the recent past and water tables in their wells dropped markedly in 1953 and 1954 which were dry years. As a result of such experiences, many of the plants installed expensive recycling equipment, and many carried out surveys to increase their efficiency of water use. As a result, a number of the plants reported that they were now using less water than in 1954, despite the fact that their output and employment had increased in the meantime. Nevertheless, the magnitude of population and economic growth expected in the next sixteen years in subregions I and V, and the accompanying increase in the amounts of water used, necessitates a more detailed and thorough examination of ground as well as surface water[30] supplies in these subregions. At present, such information is lacking. The writer does not consider the situation to be such as to demand similar surveys in the other subregions in the immediate future. However, a review of these conclusions should be made in five years when better information may be available to help in making a reappraisal.

Finally, throughout the region there was evidence that municipalities did not have adequate pumping or water distribution facilities, or that well fields currently used were not large enough. In many cases, there was evidence of poor planning insofar as the

[29] Recycling is not considered here because the water-use figures are in terms of prime water used; neither are the possibilities of supplementing total water supply by tapping other watersheds outside the region discussed in this paper.

[30] Here one may consider the surveying and leasing or purchasing of sites suitable for future reservoirs.

TABLE 13.—USE, SOURCES, AND AVAILABILITY OF WATER IN THE MUSKINGUM REGION AND SUBREGIONS IN 1955 AND 1975, IN MILLION GALLONS A YEAR

	Subregion I	Subregion II	Subregion III	Subregion IV	Subregion V	Region
			1955			
Use						
Domestic and non-manufacturing	12,389	11,763	5,894	4,339	2,808	33,035
Steam electric	—	—	—	345,400	—	354,400
Manufacturing	45,775	10,513	2,926	20,840	3,212	83,263
Total use	58,164	22,276	8,820	379,579	6,020	470,698
Source						
Surface	29,564	5,676	1,820	373,579	3,900	416,160
Ground	28,700	16,600	7,000	5,900	2,120	54,538
Total	58,164	22,276	8,820	379,579	6,020	470,698
Availability						
Water year 1954	16,300	20,400	60,400	73,700	5,000	73,700
Mean stream flow	31,500	43,400	141,700	185,000	16,100	185,000
			1975			
Use						
Domestic and non-manufacturing	23,572	12,280	7,819	6,011	4,311	53,993
Steam electric	—	—	63,500[1]	354,400	—	417,900
Manufacturing[2]	51,305	15,375	14,721	29,958[3]	4,947	116,306
Total use	74,877	27,655	86,040	390,369	9,258	588,199
Availability						
Water year 1954	16,300	20,400	60,400	73,700	5,000	73,700
Mean stream flow	31,500	43,400	141,700	185,000	16,100	185,000

[1] Data obtained on a power plant now being built near Coshocton.
[2] Water use for manufacturing is the mean between the two estimates given for each subregion and the region in the Series I water use estimates.
[3] Of this total, some 23.8 billion gallons of water will be drawn from the Ohio River, reducing the total amount of water *used and obtained* from the Muskingum watershed in 1975 to 366.6 billion gallons.

municipal authorities were incapable of anticipating future growth of water uses, and providing the necessary money to install new pumping equipment, additional water distribution facilities, or the finding and construction of new well fields. Attention should be given to these aspects in another study designed to investigate the adequacy of municipal water supplies and facilities in the Muskingum region. In such a study, the question of supplying water on a regional rather than a municipal basis may be considered.[31]

[31] In other words, such a study could consider whether it is feasible and desirable for a number of towns to cooperate in establishing a well field and/or reservoirs which would take care of their joint future water needs. Consideration should also be given to when such a regional cooperative scheme could and should be instituted.

THE CONFLICT BETWEEN FISH AND POWER RESOURCES IN THE PACIFIC NORTHWEST

M. E. MARTS
University of Washington
W. R. D. SEWELL[1]
Canadian Government

THE assumed incompatibility of two major resources—fish and power—constitutes one of the major obstacles to the development of the water resources of the Pacific Northwest of the U.S. and threatens to become a problem of even greater magnitude in British Columbia.[2] Traditionally the problem has been regarded as a choice between two mutually exclusive uses of the waters of certain streams in the region. These streams currently support large runs of migratory fish which provide the basis for one of the most important industries in the Pacific Northwest. These streams also represent important hydroelectric power resources. The conflict arises because hydroelectric power dams are barriers to fish migration, and, claim the fisheries agencies, constructed in sufficient numbers, would lead to the extinction of the fish runs.

Viewed as a choice between two mutually exclusive alternatives, the fish–power problem tends to lose perspective and hinders the development of solutions to the problem. In the broader context of river basin development, fish maintenance is but one of several possible uses of the waters of the basin. Reservation of these waters for fish migration alone may preclude the development of other desirable and complementary water uses, such as power generation, irrigation, and navigation. Actually, fish and power are not mutually exclusive uses in all circumstances, and some dams have been of benefit to fish maintenance.

The result of the fish–power conflict has been continued delays in developing the water resources of the Pacific Northwest. With fisheries agencies and power agencies firmly entrenched in opposite camps, prospects of the early development of mutually acceptable solutions to the problem are small. But failure to find a solution to the problem in the near future will present the Pacific Northwest with a choice between two alternative courses of action, both of them unsatisfactory.

On the one hand, the region may be forced to turn to more expensive means of generating power and so lose an important natural competitive advantage it has over the rest of the nation. On the other hand, pressure for the development of hydropower and other water uses may become so great that such development may proceed without a satisfactory solution to the fish maintenance problem.

The purpose of the present paper is to point out some of the broader implications of the fish–power problem and to suggest some neglected aspects which merit consideration by policy makers.

ORIGINS OF THE PROBLEM

In the space of less than a century the Pacific Northwest has been transformed from an outpost of Western civilization to a region which enjoys one of the highest standards of living in the world. In this evolution, the development of both the fishery resources and the hydropower resources of the region have played a vital role, and it was only recently that the two came into conflict.

Fishing has always been a basic activity in the Pacific Northwest.[3] Today, the fishing industry employs as many as 100,000 persons during seasonal peaks and yields an average annual gross income to fishermen of approxi-

[1] The opinions expressed are personal, in no way reflecting views of the Canadian government.

[2] For discussions of possible effects of power dam construction on the Fraser River salmon runs, see E. S. Pretious, L. R. Kersey, and G. P. Contractor, *Fish Production and Power Development on the Fraser River* (B. C. Research Council, Vancouver, B. C., 1957), and Fraser River Board, *Preliminary Report on Flood Control and Hydro-Electric Power in the Fraser River Basin* (Victoria, B. C., June, 1958), pp. 141–52.

[3] Joseph A. Craig and Robert L. Hacker, *The History and Development of the Fisheries of the Columbia River*, U. S. Dept. of the Interior, Bureau of Fisheries, Bulletin 32 (Washington, D. C., 1940), p. 212.

mately $30,000,000.[4] The fishing industry ranks fourth among the basic extractive industries of the region.[5] Salmon fishing accounts for more than half the value of the region's fishing industry, and the Columbia River has traditionally been the major single source of salmon.

Survival of the salmon fishing industry, however, is threatened by a number of factors of which the encroachment of civilization is perhaps the most potent. The Columbia River provides a good illustration of this encroachment. The various developments which have accompanied the expansion of population in the region—such as industrialization, irrigation, and hydropower generation—have all had serious effects on the maintenance of the Columbia's fishery resources.

From a record Columbia River salmon catch of 43,000,000 pounds (895,800 cases) in 1883, yields fell to an all-time low of 119,057 cases in 1954.[6] Although there has been some improvement in runs since that date, production is far below that in record years (Figure 1). There are fears that yields will fall even further if more dams are constructed on salmon streams in the Pacific Northwest.

THE GROWING DESIRE FOR POWER

The economy of the Pacific Northwest is still in a relatively pioneer stage of development, with major emphasis on extractive and primary processing rather than on secondary manufacturing and service industries. As a consequence, the region has experienced violent fluctuations in activity, and efforts have been made toward developing a more stable and diversified economic structure. The provision of an adequate energy supply has been regarded as a fundamental prerequisite in achieving this end.

The hydroelectric power potential of the region, including Columbia River tributaries in Montana, is estimated by the Bonneville Power Administration at 36 million kilowatts, which is about one-third of the total hydropower potential of the United States. Over 7 million kilowatts have been developed so far and projects with an additional 6 million kilowatts are under construction. How much of the remaining 23 million kilowatts will be harnessed depends on a number of factors, foremost among which are construction costs, the availability of alternative sources of energy, public policy with respect to resource development, and the resolution of various conflicts of interest.

At present, hydropower is the cheapest means of producing electrical energy in the Pacific Northwest and it appears that it will remain the principal source for some time to come. Power produced from hydro sources is being sold by the Bonneville Power Administration at wholesale rates of two to three mills per kilowatt-hour. Power produced from alternative sources, such as coal, oil, natural gas, or uranium, would cost significantly more. The region possesses reserves of fossil fuels but costs of exploitation are high and supplies are imported from elsewhere. Costs of imported fuels, however, are not low enough to enable thermal power to compete with hydropower. Despite the tremendous advances that have been made in nuclear power technology, it seems unlikely that this means of generation will assume a truly dominant role in the Pacific Northwest for many years to come.[7]

[4] Source: Washington State Department of Fisheries and Oregon State Fish Commission.

Estimation of "normal" employment in fishing and fish processing is difficult because of the highly seasonal nature of the industry, the high proportion of part-time self-employment, the uncertainty of reporting procedures, the exclusion of employment in sports fisheries, and the integration of Washington with Alaskan and high seas fisheries. The above figures would be much lower if expressed as annual-full-time-equivalent employment. Thus, using data from the Washington State Employment Security Department, and the Oregon Department of Employment, average monthly employment estimates have been derived as follows: fishing, 2,007; canning and curing seafoods, 3,077; and packaging fresh or frozen fish, 917 employees. These figures are the averages of employment as reported in twelve weeks, one week in each month, for Washington and Oregon during 1958. The figures represent persons covered by unemployment insurance; as such, they include some but not all self-employed persons.

[5] After forestry, agriculture, and tourism.

[6] *Pacific Fisherman Yearbook*, January 1959. The Columbia River salmon pack represents approximately 70 percent of the total Columbia River salmon caught commercially. For example, in 1958, canned salmon amounted to 6,552,384 pounds, compared with a frozen salmon pack of 2,990,115 pounds.

[7] Most estimates of probable costs of nuclear power are in the nature of speculations. Generally they represent goals toward which nuclear power engineers must strive rather than costs based on actual experi-

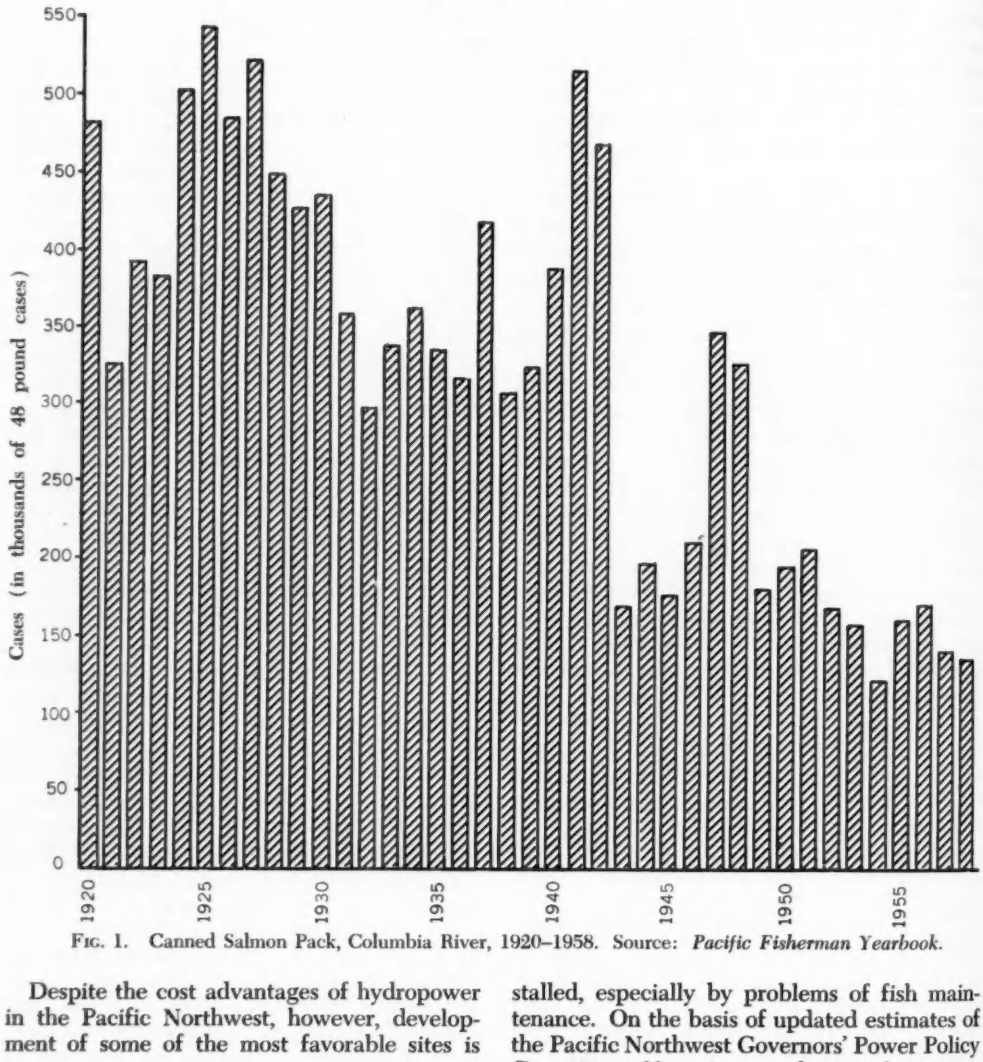


FIG. 1. Canned Salmon Pack, Columbia River, 1920–1958. Source: *Pacific Fisherman Yearbook.*

Despite the cost advantages of hydropower in the Pacific Northwest, however, development of some of the most favorable sites is stalled, especially by problems of fish maintenance. On the basis of updated estimates of the Pacific Northwest Governors' Power Policy Committee, 22 projects with a total capacity of 5,000,000 kilowatts are being held up by fisheries problems.[8]

If the Pacific Northwest is to take maximum advantage of its water resources, earnest efforts must be made to find a solution to the fish–power conflict. It is pertinent at this point to examine what measures have been carried out so far, to comment on their effec-

ence. Many of them are based on assumptions regarding technical advances which have yet to be made. For discussions of the problem of estimating nuclear power costs, see D. P. Herron and A. Puishes, "The Prospects for Economic Atomic Power," Paper presented to the A.S.M.E. Semi-Annual Meeting, San Francisco, California, June 9–13, 1957; H. W. Nelson and W. R. Keagy, Jr., "The Economic Background for the Competitive Development of Nuclear Power," paper presented at the Second Nuclear Engineering and Science Conference, Philadelphia, Pa., March 11–14, 1957; and John Davis, *Canadian Energy Prospects,* Royal Commission on Canada's Economic Prospects (Ottawa, 1957)

[8] Pacific Northwest Governors' Power Policy Committee, *Status Report on the Relation of Fish and Wildlife Problems to New Hydro Power Development,* Portland, Oregon, November 4, 1954, p. 5.

tiveness, and to suggest additional measures which might be undertaken.

EFFORTS TOWARD FISHERY REHABILITATION AND DEVELOPMENT

The serious effects of encroaching civilization on resources in general were recognized by conservationists and others in the late 19th century, and various policies have been put into effect since that time to promote better utilization of our forests and farmlands. But it was not until the era of large dam construction on the Columbia River that really positive measures for rehabilitation and development of the fishery resource were initiated.[9] Through the programs of research and development, which have been carried out since the 1930's, it has been possible to gain a clearer understanding of the problem and to implement programs designed to increase, rather than merely rehabilitate, the fisheries.

Measures intended to offset losses due to hydro dam construction and to increase the Columbia River fishery may be grouped conveniently as follows: (1) fish-passage facilities, (2) fishing regulations, (3) sanctuary stream programs, and (4) research programs.

Fish-passage facilities have been installed at all main-stem dams downstream from Chief Joseph Dam in an effort to avoid or minimize fish losses at these dams. Although fish ladders may permit the safe passage of large numbers of fish, losses of both upstream and downstream migrants occur. The success of fish-passage facilities, therefore, is not yet assured. They are, moreover, very expensive and not considered technically feasible at high dams (such as Grand Coulee or the proposed Nez Perce dams). As of now they should be regarded as experimental expedients designed to prevent complete elimination of fish runs and applicable only at dams of low or moderate height. Combined with other measures, however, the passage facilities may be instrumental in the restoration of the Columbia River fishery.

Recognition of the serious depletions in fish runs due to overfishing resulted in the enactment of laws restricting the use of various types of fishing gear, and confining fishing to certain seasons and certain areas. Because of the international nature of the problem, treaties with other nations have also been drawn up. The International Pacific Salmon Fisheries Commission was established in 1937 by the United States and Canada and the Pacific Marine Fisheries Commission in 1947 to provide for international regulation.

While regulation has probably done much to prevent further decline of the fishery, much more positive measures are required to rehabilitate it to former levels. At the same time, provision has to be made to compensate for additional losses that are likely to result from further dam construction on the main stem of the Columbia River.

A promising compromise was developed by the U. S. Corps of Engineers and the U. S. Fish and Wildlife Service in the Lower Columbia River Fisheries Development Program, which was begun in 1949. These agencies considered that if the comprehensive plan for the Columbia River were fully implemented, the salmon spawning grounds of the upper part of the Columbia Basin would be lost. They decided that the best alternative would be to depend mainly on the tributaries of the lower river and upon artificial propagation for the development of the salmon and steelhead runs of the Columbia River.[10] The program has two aspects: (1) enhancement of habitat and access conditions and development of means to supplement natural propagation; (2) protection of fish runs through setting aside streams as sanctuaries or fish preserves.

To date, the enhancement aspect has been largely implemented. Most of the stream clearing work to improve habitat has been completed, several fishways have been constructed, eight new or rebuilt hatcheries placed in operation,[11] and fish farming programs initiated. To implement the sanctuary

[9] For a description of programs for rehabilitation and development, see U. S. Columbia Basin Inter-Agency Committee, Fisheries Steering Committee, *The Fisheries and the Multiple Purpose Development of the Columbia River* (Portland, Oregon, January, 1955).

[10] U. S. Department of the Army, Corps of Engineers, *Review Report on the Columbia River and Tributaries, Northwestern United States.* H. Doc. 531, 81st Cong., 2nd Sess. (Washington, D. C., 1952), Apendix P, p. 2919. All tributaries of the Columbia River below McNary Dam are included in the sanctuary stream program.

[11] About 20 hatcheries are now operating in the Columbia River basin.

concept the state legislatures of Washington and Oregon enacted fish refuge laws forbidding the construction of high dams on the lower Columbia Basin tributaries. Conflicting legal authority and jurisdictions, however, threaten the sanctuary concept. Specifically, the U. S. Federal Power Commission has licensed high power dams on the Cowlitz and Deschutes rivers, both recognized as sanctuary tributaries by the states and by the U. S. Fish and Wildlife Service.

Much of the hope in rehabilitating the fisheries can be attributed to the research programs undertaken by various international, federal, state, and private agencies and by the universities.[12] These programs have involved the expenditure of several millions of dollars. The Columbia River Fisheries Engineering Investigation and Research Program of the Corps of Engineers, for example, is estimated to cost between 2 and 3 million dollars.[13] The research is being undertaken to discover behavior of salmon under natural and man-made conditions. From the results of the research it is hoped that it will be possible not only to compensate for losses which result from the encroachment of civilization but also to make unaffected areas more productive than they are at present.

DIFFICULTIES IN RESOLVING THE FISH–POWER CONFLICT

The various programs which have been initiated to rehabilitate the salmon fishery of the Columbia River appear to be meeting with some success, and results of research programs indicate possibilities by which the fishing may be increased to levels several times those achieved today. Despite the large expenditures on research and the indications of success of many of the programs of rehabilitation, however, the conflict of fish and power seems to be far from a mutually acceptable solution, and as time goes on the likelihood of reaching a compromise seems to diminish. Foremost among the factors which tend to perpetuate the problem are: (1) the historic importance of the fishing industry in the Pacific Northwest, (2) inappropriate comparisons of values of fish and power, (3) increasing costs of fish preservation, and (4) the time required to study the biological aspects of the problem.

In view of the historic importance of fishing, and particularly salmon fishing, in the Pacific Northwest, it is understandable that the fisheries agencies are unwilling to sanction schemes which threaten to deplete the resource. They claim that once a run has been damaged, it may be impossible to rehabilitate it. As a consequence, even though results of research may suggest attractive means of compensating for fish losses, fisheries agencies may continue to oppose hydropower projects.

Another factor which tends to aggravate the fish–power problem is the attempt by the fisheries and power agencies to compare the monetary values of fish and power. Generally, little resort to economic analysis is made in such comparisons and many of them are based on highly unrealistic assumptions and grossly inflated figures. For example, the fisheries agencies have sometimes assumed that the installation of one dam will mean economic ruin to the fishing industry. Thus evaluations often compare the value of the power from the one dam with the value of the product of the entire fishing industry. In reality, of course, only part of the fishery would be affected. On the other hand, evaluations made by the power agencies seldom take into account long-run values of the fishery or the effect of the present investment in boats, gear, and other capital equipment.[14]

[12] For a description of various research programs being undertaken see H. A. Preston and Lewis E. Rydell, "The Co-existence of Fish and Dams," *Transactions of American Society of Civil Engineers*, Journal of the Power Division, October, 1957.

[13] U. S. Dept. of the Interior, Fish and Wildlife Service, *Statement in Response to the Request, November 20, 1953, of Senator Styles Bridges on the Abundance, Distribution, and Value of the Columbia River Fish Runs, the Effect of Dams on these Runs, and Certain other Related Information*, Portland, Oregon, December 1953, p. 34.

[14] For an objective estimation of the income from and capitalized value of Washington fisheries, see James A. Crutchfield, "Economic Value of Washington Commercial Fisheries, 1955," *Pacific Northwest Business*, July 1957, pp. 5–15.

Crutchfield's estimates are for the state of Washington, and so do not contribute directly to comparisons of the economic returns of fish and power on the Columbia River. A careful estimation of relative values is beyond the scope of this paper, and is difficult because of various uncertainties, including the intangible values of fish caught by sports fishermen. A rough comparison of gross income, however, may be developed. A U. S. Fish and Wildlife Service estimate prepared for Senator Styles Bridges in 1953

The net result of this type of comparison is to keep the fisheries agencies and the power agencies far apart and to preclude the possibility of compromise. Much more objective analyses of the values of fish and power involved at proposed hydro projects must be developed. Only then can the economic aspects of the problem be properly evaluated and weighed *with other considerations* in the decision-making.

The importance of developing better evaluation techniques is emphasized by the increasing concern that has been expressed regarding the mounting costs of fish preservation in the Pacific Northwest. It has been estimated that over $127 million has been invested in facilities to protect Columbia River salmon since Rock Island Dam was constructed in 1933.[15] While expenditures at dams constructed to date have been large, such expenditures at dams constructed in the future may be even greater. For example, the Bonneville fish facilities cost about $7 million, whereas those at The Dalles Dam cost $18 million and those at McNary Dam cost over $27 million. The question has been raised as to whether these expenditures are justified.

It is not generally realized that as development in the basin proceeds, investment in fish facilities yields diminishing returns. As further dams are added, costs of preservation increase, but the number of fish preserved diminishes (although the value of the individual surviving fish may increase). This effect takes place because, even with the most efficient facilities so far devised, losses of migrants occur at each dam. Thus these losses tend to be cumulative both on the upstream and the downstream migrations, so that if sufficient dams are added, the whole run may be eliminated.[16] Eventually a stage is reached where the cost of preserving the fish exceeds the value of the fish preserved. Further investment in fish facilities beyond this point cannot be justified on economic grounds.[17]

Unfortunately, very little attention has been paid to economic analysis in decisions relating to expenditures on fish maintenance programs. The decisions have been based mainly on the technical feasibility of the facilities rather than on their economic feasibility. The result has been to obscure the problem of diminishing returns of such investments, and to divert attention from consideration of alternative schemes of fish preservation, such as relocation of fisheries, transport systems other than fish ladders, and fish preserves. In addition, no consideration appears to have been given to alternative employment of the labor and resources now employed in this segment of the fishing industry.

A fourth factor which tends to perpetuate the fish–power conflict and which inhibits a solution to the problem is the manner in which the time element affects the two groups of interests involved. The fisheries agencies have been interested primarily in the biological aspects of the problem, and their studies have concentrated mainly on the behavior and biology of the fish, as well as on the effects of dams on fish runs and on means of getting fish over dams. Because of the complexity of the problems, such studies involve great detail and are carried out at a wide variety of locations. Although these studies are essential to good solutions, they are very time-consuming and the general result is to push the

(*supra*, p. 6) places the value of Columbia River salmon and steelhead at $17,012,000 per year, based on average annual catch data for 1938–42 (catches in recent years have been much lower). By way of comparison, the Bonneville Power Administration's revenue from sale of power in 1953 was $38,442,000 (and in 1959 was nearly $67,000,000). This comparison does not constitute an economic evaluation, however, and must be used with great caution. For instance, it does not evaluate all effects that should be considered in making decisions, the values are gross rather than net, and the measurements are not at the same points in the chain from production to consumption.

[15] The $127 million includes costs of installing fishways, hatcheries, and conducting experiments designed to maintain the runs. See Bob Woods, "Kilowatts and Salmon," reprinted series of articles in the *Wenatchee Daily World*, Wenatchee, Washington, February 27–March 10, 1958, p. 1.

[16] The problem of fish losses is very complex and is related not only to the physical problem facing the fish in passing the dam, but also to changes in environment both upstream and downstream from each dam. These environmental changes involve such items as water temperature, predation, currents, siltation, etc. See, for example, C. H. Clay and P. A. Larkin, "Artificial Propagation is NOT the Answer," *B. C. Professional Engineer*, March 1959, pp. 20–23.

[17] M. E. Marts and W. R. D. Sewell, "The Application of Benefit–Cost Analysis to Fish Preservation Expenditures: A Neglected Aspect of River Basin Investment Decisions," *Land Economics*, February 1959, p. 48.

resolution of the conflict even further into the future.

Meanwhile the power agencies, conscious of the problem of meeting rapidly growing power demands, are becoming increasingly impatient of time required for biological studies. Faced with an inflationary construction cost spiral, these agencies realize that prospects of taking maximum advantage of certain undeveloped cheap power sites in the Pacific Northwest are fading. They are also conscious of the real costs involved in adopting more expensive means of generation and truncating hydropower development, with the consequent inhibition of industrial and commercial growth. The power agencies are anxious to proceed with construction of high dams at sites such as Mayfield on the Cowlitz River and Nez Perce or Mountain Sheep on the Snake River, even though the fish–power problems involved at these sites are among the most intractable in the Pacific Northwest.

NEGLECTED ALTERNATIVES

In addition to the approaches already discussed—namely, fishing regulation and sanctuary stream programs—there are a number of other at least theoretical possibilities for compensation which merit consideration. These include the development of runs on non-power streams, the development of alternative fisheries, and the provision of alternative occupations for fishermen. Although such alternatives would be expensive, they should not be rejected *a priori*. It has been noted that very large expenditures are planned for fish ladders without assurance of success. Careful investigation might or might not indicate that such sums could more effectively be invested in alternative schemes.[18]

Construction of certain hydropower projects may make it impossible to maintain fish runs in some parts of the basin. In some circumstances it may be possible to compensate for losses by relocation of runs and artificial propagation. The Grand Coulee Fish Maintenance Program, which was based on this approach, has achieved a measure of success. There may be attractive opportunities for such schemes, not only in the Pacific Northwest, but also along the British Columbia coast and in Alaska. Such possibilities, of course, are limited by the size and the nature of the run to be relocated.[19] While a program may achieve considerable success in one area, it may be a complete failure elsewhere. What is important, however, is that all possibilities be considered and thoroughly investigated.

It is possible that more intensive development of the Alaska fisheries might offset some of the losses which are expected to result from the installation of dams on the Columbia and Snake rivers. Currently the Alaska salmon pack is about 20 times the size of the Columbia pack, 3,347,446 cases versus 161,731 cases (Table 1). The U. S. Fish and Wildlife Service believes that "Intelligent management of resources, based on scientific knowledge, would increase the annual production in Alaska by at least 50 million pounds (1,041,000 cases)."[20] This represents a 31 percent increase over the 1948–55 average annual canned salmon pack of Alaska. Development in Alaska seems particularly attractive since conflicts with other resource developments such as agriculture, forestry, and hydroelectric power, are minimal and there is an abundance of suitable streams for spawning throughout the area.

No mass migration of fishermen and their families would be necessitated by the development of fisheries in Alaska. Much of the Alaska fishery is now carried on by fishermen from Oregon and Washington who go north each summer to fish for salmon in Alaskan waters. Part of this migration is a regular annual migration, and part of it is governed by fishing prospects in the Pacific Northwest as compared with those in Alaska. The development of fish runs in Alaska would probably not be opposed by a large number of Wash-

[18] Implicit in this discussion of alternatives is the assumption that compensation for damage to fishery resources will be made, and that the problem is to find the most efficient means of compensation. The justification for compensation involves social and philosophical as well as economic considerations and is beyond the scope of this paper. The feasibility of significant compensation is suggested, as indicated, by the large investments now being made in fish-passage facilities.

[19] C. H. Clay and P. A. Larkin, *op. cit.*, discuss the magnitude of the problem of compensating for losses which might result from power developments on the Fraser River in British Columbia.

[20] U. S. Department of the Interior, Fish and Wildlife Service, *Fishery Resources of the United States* (Washington, D. C., 1945).

TABLE 1.—CANNED SALMON PACK—COLUMBIA RIVER, ALASKA, UNITED STATES, AND BRITISH COLUMBIA, 1920–1958[1]
(in cases of 48 pounds)

Year	Columbia River	Alaska	United States	British Columbia
1920	481,545	4,395,509	5,101,705	1,187,616
1	323,241	2,604,973	3,622,612	603,548
2	392,174	4,501,355	5,231,675	1,290,326
3	380,925	5,063,340	6,411,757	1,341,677
4	500,872	5,305,923	6,245,320	1,745,313
5	540,452	4,450,898	6,034,321	1,720,622
6	479,723	6,652,882	7,491,684	2,065,198
7	519,809	3,566,072	5,053,472	1,360,449
8	446,646	6,070,110	6,902,447	2,035,637
9	422,117	5,370,242	6,983,556	1,400,750
1930	429,505	4,988,987	6,044,093	2,221,783
1	353,699	5,432,535	6,780,492	685,104
2	296,191	5,260,488	5,914,853	1,081,031
3	336,711	5,226,698	6,360,742	1,265,072
4	362,721	7,470,586	8,361,990	1,582,926
5	332,739	5,155,826	6,037,454	1,529,022
6	316,445	8,454,948	8,983,217	1,881,026
7	416,830	6,654,038	7,526,197	1,509,175
8	307,990	6,791,544	7,274,209	1,707,830
9	322,472	5,293,211	5,971,527	1,539,070
1940	386,999	5,028,378	5,548,908	1,467,227
1	513,712	6,906,503	7,779,654	2,248,870
2	464,401	5,089,109	5,852,515	1,811,560
3	167,660	5,396,509	5,676,391	1,258,221
4	196,762	4,877,796	5,119,079	1,097,557
5	175,670	4,341,120	4,910,580	1,739,311
6	209,471	3,971,109	4,563,115	1,348,138
7	347,306	4,302,466	5,612,664	1,533,478
8	324,242	4,010,612	5,826,426	1,308,137
9	178,122	4,391,051	5,524,916	1,436,464
1950	192,990	3,272,643	4,274,462	1,482,560
1	203,123	3,484,464	4,645,570	1,956,397
2	167,616	3,574,128	4,455,022	1,293,435
3	153,199	2,925,570	3,910,646	1,825,267
4	119,057	3,207,154	4,163,147	1,742,736
5	161,557	2,457,969	3,361,885	1,406,100
6	167,121	2,950,354	3,432,658	1,118,279
7	138,016	2,441,894	3,184,897	1,449,120
8	136,508	2,948,371	3,706,636	1,908,056
Average, 1948–58	161,731	3,347,446	4,065,937	1,558,556

[1] Source: *Pacific Fisherman Yearbook*, January, 1959.

ington and Oregon fishermen. There might be substantial opposition, however, from fishermen who do not take part in the Alaska migration, and by fish handlers and processors who are dependent mainly on Columbia River salmon, and whose investment is immobile and specific to the Columbia River fishery.

In addition to a geographical re-orientation of production, it is possible that research may reveal or develop species and varieties of fish which are able to adapt themselves to the new conditions in the basin. Experiments in selective breeding and hybridization being conducted at the University of Washington indicate that it is possible to develop races of fish which are not only larger and stronger than present races but are also able to reproduce within a shorter cycle. In addition, the possibilities of fish farming techniques merit much more attention than they have been given to date.[21]

A further possibility of compensating fishermen for the loss of salmon runs would be to develop alternative occupations in fishing communities, perhaps by subsidizing other industries. The salmon fishing industry has experienced wide fluctuations in the price of its product in the past, and in the volume of its catch. In consequence, there has been much economic instability in fishing communities depending on fishing for the main source of their income. The development of alternative occupations in such communities would serve the double purpose of helping to diversify the economy and to compensate for losses of income which result from depletions of the fish runs. A scheme based on the approach of the Development Area program in Great Britain merits consideration in this connection. Through lower taxes, provision of capital funds on attractive terms, and other amenities, the British government made formerly depressed areas attractive as locations for new industries. Typically, the industries which took advantage of the program were footloose industries, employing unskilled and semi-skilled labor.[22] The problem of unskilled labor was overcome to some extent by vocational training schemes.

Another avenue of compensating for the social effects of depletion of salmon runs lies in the possibility of developing the markets for non-anadromous fishery resources. The

[21] For a discussion of possibilities of artificial propagation and fish farming see Milo Moore, *Salmon Fisheries of the North Pacific Ocean*, Washington State Department of Fisheries, April, 1959.

[22] For a discussion of the Development Area program see S. R. Dennison, *The Location of Industry and the Depressed Areas* (Oxford University Press, 1939), and G. R. Allen, "The Growth of Industry on Trading Estates, 1920–1939," *Oxford Economic Papers*, Vol. 3, No. 3 (October, 1951).

traditional specialization on salmon in the Pacific Northwest has obscured the potential importance of other available species, such as herring, cod, sole, and flounder. Although these have not been prized so highly by the market as salmon, they do represent potentials for partially offsetting sources of income.[23]

CONCLUSIONS

Much of the basis for the long-standing difficulty in finding acceptable solutions to the fish and power problem has been the concern of protagonists that the opposite camp was claiming special treatment on the basis of special, subjective values. This has led to viewing the problem as a forced choice between mutually incompatible uses of the water resource, and inhibition of the consideration of alternative solutions or methods of compensation.

In the broad context of river basin development, fish maintenance is one of the several possible uses of the waters of a basin. Many of these uses may be complementary or at least compatible. In the case of fish, compatibility with other uses may be more difficult, and perhaps impossible to achieve at given sites or within given reaches of a river. But given sound planning, compatibility within the broad framework of comprehensive river basin and regional development may well be possible.

Sound planning in river basin development presupposes careful and objective evaluations of the costs and benefits of alternative developments; application of optimization criteria in which economic values are important but are not the only values to be considered; and a willingness to consider alternatives before fixing on a course of action. The failure to consider these factors has been the major reason for the prolonged conflict. Until such considerations are developed into policy and then implemented, optimum use of Pacific Northwest rivers cannot be achieved.

[23] The herring, for example, is an important food fish in Europe but in northwest North America is taken primarily for production of meal and oil.

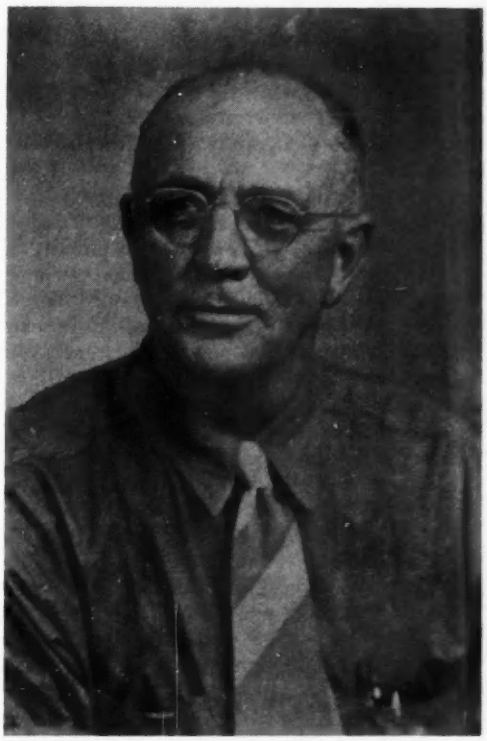
WELLINGTON DOWNING JONES, 1886–1957

CHARLES C. COLBY
Southern Illinois University

MUCH of the life and work of Wellington D. Jones was associated with the University of Chicago. His parents lived near the University and Wellington progressed successively and successfully up the academic ladder from kindergarten to the doctorate. At the undergraduate level he played on the football team, became a prominent man on the campus, and made a fine scholastic record. Rather late in his undergraduate program he discovered geography and thereby came to the attention of Professor Rollin D. Salisbury, then Head of the Department of Geography. Wellington planned to become an architect, and after graduation at Chicago enrolled for that purpose at Massachusetts Institute of Technology. In 1908, however, he gave up his architectural plans in view of an offer to teach and study geography in the new department at Chicago.

In measuring Wellington's subsequent contributions to geography, it is essential to recognize the vigorous scholarly atmosphere into which he stepped. Professor Salisbury, Professor of Geographic Geology and Dean of the Ogden Graduate School of Science, was widely recognized as a scientist, a writer, and a teacher of outstanding distinction. Other members of the staff included J. Paul Goode in economic geography and Harlan H. Barrows in historical geography. High standards of teaching and research were the rule and these exerted a highly constructive impact on Wellington and other students of that early period.

In his early years as a geographer (1908–21), Wellington Jones enjoyed such exceptional opportunities for field study that his experience differed in this respect from most other young geographers. In the first term of the summer quarter in 1909 he took the Baraboo field course in geology with A. C. Trowbridge, a remarkably effective teacher in the field, and taught the course in the second term. Later in 1909, under the title of "scientific explorer," he led a field party from the Geographic Society of Chicago in a study of Yellowstone National Park. In 1910 he assisted



WELLINGTON DOWNING JONES, 1886–1957

W. C. Alden in a study of the glacial geology of the Green Bay Lobe.

Other field experiences followed. One of major significance in Wellington's career resulted from a course offered by Bailey Willis when he came to the University as a visiting professor in 1910. Wellington took the course and gained much from his association with this distinguished leader in the earth sciences. In his turn, Professor Willis recognized Wellington's potentialities, and in 1911, when the government of Argentina invited Willis to direct a commission to survey the water resources of Northern Patagonia, Wellington was hired as a member of the survey staff. Wellington's assignment "to study possibilities of further economic use of the area" not only provided training in field methods but turned his thoughts to economic geography, a divi-

sion of geography in which he subsequently made many contributions.

After the two years spent with the Northern Patagonia survey, Wellington returned to the University as an instructor in geography. As he had gathered a wealth of material from the field and from contacts with agencies of the Argentina government, he began active work on his doctoral dissertation under the title "Studies in the Geography of Northern Patagonia."

In 1913, Wellington married Harriet Harding, daughter of a prominent Chicago family. For their honeymoon they spent six months in 1913 at the University of Heidelberg, where Wellington worked with Professor Alfred Hettner. During this period of European study, Jones spent two weeks in the Moselle Valley with Professor Hettner and a month in the Swiss Alps with Professor Phillipson from Bourn. These experiences profoundly influenced Wellington's ideas of geography, as did discussions of methods and content while he was a member of Professor Barrows' field party in the Southern Appalachians in 1914.

After receiving his doctor's degree in 1914, and with a generous grant from the Swift family, Dr. Jones spent many months in the study of eastern Asia. He visited Japan, China, Manchuria, and Mongolia. He traveled overland from the Yangtze to Canton in South China. From this trip through the hills of China came a conviction that, since much of China could not be described as plains, plateaus, or mountains, a new landscape term was needed. Hence he introduced the term "hill country" into his geographic vocabulary.

Jones's work in eastern Asia was followed in 1920–21 by travel and study in India, again under financial assistance from the Swift family. In this work he was helped by contacts with government officers and agencies, and thereby amassed great quantities of maps and documents. He made a special study of Kashmir and did considerable field mapping in that area. Throughout his work in India, he typed a daily record and sent a copy to Chicago, where it went the rounds of the staff and special students.

Dr. Jones's experiences in East Asia and India greatly increased his knowledge of world geography. His studies led to the realization that regions, like men, differ in resources and potentialities. The densely peopled areas of China and India, he noted, stand in sharp contrast with the nearly empty plains of Patagonia or the highly industrialized sections of Western Europe. Moreover he was so impressed with the contrasting sections within China and India that subsequently he recognized and mapped their major geographic divisions.

Through the years Dr. Jones devoted much time and effort in perfecting the technology of field and regional investigations. Moreover, he was a prime mover in organizing a "Spring Conference" of Middle Western geographers to experiment with field mapping. For fifteen years this conference met on the third weekend in May, each year at a different point.[1] Among other things this group developed the "Fractional Code" method of field mapping. This method calls for the use of air photographs as a base, preferably single lens mosaics. Jones was a leader in this group enterprise, both because of his interest in the method and his enthusiasm for improving geographic field studies.

In discussing field methods and techniques with his students and contemporaries, Dr. Jones always emphasized the importance of detailed field notes. He expressed this approach in some notes written in 1951 with regard to his field work in northern Patagonia. In abbreviated form these notes are quoted herewith:

> I well remember Bailey Willis' instructions before my first long field trip from Rio Colorado to Valcheta. Willis in effect said that I was to travel across the country as rapidly as I could on horseback and still see the general aspects of the countryside, and that as I traveled I was to stop at a few widely separated points, take detailed observations, and make notes thereon; each such stop to be located accurately on a map. . . . This method is, in my way of thinking, the most valuable we know in geography in the field . . . for many years I have employed it with identifying digit notations. . . . On this first traverse of 150 miles I plotted my observations, and when later our topographers determined the latitude and longitude of Valcheta my plotted traverse was out only a small fraction of an inch, which failure to close I adjusted (spread back over the 150 miles).

[1] At the outset in 1923 this group included Sauer, McMurry and D. H. Davis from Michigan, Finch and Lobeck from Wisconsin, Hass from Northwestern, Parkins from Peabody College, and Jones, Whittlesey, Platt and Colby from Chicago. Expenses were prorated.

> . . . From such records millions of square miles on the earth have been mapped and from such maps we learn the approximate distribution of vegetation, soils, rocks, land forms, population density, and oasis and stream locations.[2]

Following his return from India in 1921, Dr. Jones began more than a decade of effective teaching, writing, and research. His courses in East Asia and India became basic instruments in training students in regional delimitation and discussion. His research during the period led him to make intensive use of his method of isoplethic mapping. Moreover, his wall map of world agricultural regions with accompanying text led to much fruitful thinking and discussion of world agriculture. During this period also the University of Chicago Press published *An Introduction to Economic Geography* by Wellington D. Jones and Derwent S. Whittlesey, a volume that introduced a highly distinctive method of undergraduate learning.

In 1933, Professor Jones was confronted with the preparation of a syllabus for a beginning course in geography as a part of the development program of "General Education" at the University of Chicago. The assignment also called for comprehensive examinations to follow the use of the syllabus. To Jones this work became a frustrating task because it diverted his thought and attention from his research and teaching. Following the completion of the syllabus and comprehensive examinations, Dr. Jones faced the first of recurring periods of illness which greatly handicapped his productive efforts.

In the latter part of his university work, Dr. Jones became greatly interested in the study of soil geography. In part this interest grew out of the "Spring Conference" on field methods and partly out of contacts with geographers at the University of Michigan and soil scientists at Michigan State University. In studying the distribution of soils, Jones found great satisfaction in Marbut's insistence that the basic approach to a knowledge of soils and other natural phenomena was through consideration of their inherent characteristics.

In accordance with his interest in the geography of mountain areas, Professor Jones spent several summers in the Rocky Mountains, more especially in the Southern Rockies. As early as 1920, he conducted a graduate field party in the Rocky Mountain National Park and later studied the glacial land forms of that area. He was an ardent fisherman and combined this type of recreation with his field studies.

Wellington D. Jones was a highly constructive figure in American geography in the first half of the twentieth century. He was a pioneer in bringing to the United States firsthand knowledge of the economic geography of East Asia and India. By means of his teaching and his creative achievements in regional mapping, he contributed effectively to the development of regional geography and the isoplethic method in the discovery of areal patterns. He possessed a highly original outlook—the outlook of an explorer of many areas of geographic thought. By his teaching, his dynamic personality, and his wide contacts in academic circles he became a colorful and constructive force in the formative period of American geography.

Dr. Jones became Professor Emeritus in Geography at the University of Chicago in 1945. He spent the next decade in study and writing at his home in Birchwood, Berrien County, on the Michigan shore of Lake Michigan. After a long illness the end came on July 24, 1957. He is survived by his wife, the former Harriet Harding, his two sons, Wellington, Jr., and Harding, and three grandchildren.

[2] These notes were sent to the author by Professor Charles M. Davis of the University of Michigan. A paragraph from Davis' letter explains the origin of Jones's notes:

"Sometime about 1950, I put together a rough draft of the Field Techniques chapter for *American Geography, Inventory & Prospect* and sent a copy to Wellington for his comments. During the next several weeks I received a remarkable collection of notes, made on old paper sacks, old letters, envelopes, or other scraps of waste paper; all in Wellington's almost unreadable handwriting. To understand the criticisms, I had all of the notes 'translated' into the enclosed pages."

Professor Davis' statement shows that although Jones was painstakingly systematic in the field, much of his correspondence made difficult reading for his contemporaries.

SELECTED BIBLIOGRAPHY

1914. "Studies in the Geography of Northern Patagonia," Thesis (Ph.D.), Ms in Harper Library, The University of Chicago, 1914. Published in abridged form as "The Present Status and Future Possibilities of Agricultural Land Utilization in Patagonia," *American Geographical Society: Pioneer Settlement*, 1933.

1915. "Outline for Field Work in Geography," *The American Geographical Society, Bulletin*, Vol. 47 (1915), pp. 520–525 (with Carl O. Sauer).

1921. "Hokkaido, The Northland of Japan," *The Geographical Review*, Vol. 11 (1921), pp. 16–30.

"Hokkaido and Its Resources," *Geographical Journal*, Vol. 58 (1921), pp. 245–246.

1925. *An Introduction to Economic Geography*. Chicago: The University of Chicago Press, 1925.

"Detailed Field Mapping in the Study of the Economic Geography of an Agricultural Area," *Annals*, Association of American Geographers, Vol. 15 (1925), pp. 148–157 (with V. C. Finch).

1928. "Glacial Land Forms in the Sierra Nevada South of Lake Tahoe," *The University of California Publications in Geography*, Vol. 3 (1928).

1929. "A Method of Determining the Degree of Coincidence in Distribution of Agricultural Uses of Land with Slope–Soil–Drainage Complexes, *Transactions of the Illinois State Academy of Science*, Vol. 22 (1929), pp. 549–554.

"An Isopleth Map of Land Under Crops in India," *The Geographical Review*, Vol. 19 (1929), pp. 495–496.

1930. "Ratios and Isopleth Maps in Regional Investigation of Agricultural Land Occupance," *Annals*, Association of American Geographers, Vol. 20 (1930), pp. 177–195.

1931. Field Mapping of Residential Areas in Metropolitan Chicago," *Annals*, Association of American Geographers, Vol. 21 (1931), pp. 207–214.

1932. "Nomadic Herding Region," *Economic Geography*, Vol. 8 (1932), pp. 378–385 (with Derwent S. Whittlesey).

"Types of Agricultural Land Occupance," *World Map*, 1932 (with Derwent S. Whittlesey).

Syllabus for Geography, Part of a Sequence prepared as an introduction to geography, 103 pp., distributed by the University of Chicago Bookstore, 1932.

1934. "Procedures in Investigation of Human Occupance of a Region," *Annals*, Association of American Geographers, Vol. 24 (1934), pp. 93–111.

1944. "Glacial Landforms in Rocky Mountain National Park, Colorado, *Journal of Geology*, Vol. 52 (1944), pp. 217–234 (with Louis O. Quam).

LETTERS AND COMMENTS ON *ANNALS* TOPICS

RIGIDITY OF RAIL HINTERLAND BOUNDARIES IN AUSTRALIA[1]

IN a substantial paper entitled "Railway Traffic Densities and Patterns," published in the December 1958 issue of the *Annals*,[2] William H. Wallace made an excellent contribution to the field of transport geography.

The second part of the paper comprises a discussion of the pattern of railroad traffic movements. Regional railnets are treated briefly,[3] and a paragraph is devoted to the unusual division of Australia into regional railnets, based on state boundaries. It is on an inference from the final sentence of this paragraph that I wish to comment. Wallace states:

> However, the evolution of Australian regional railnets has also been fostered by the establishment of separate government railway systems in the various states; and, moreover, the lack of co-operation among these state railways has resulted in the differences in track gauge and equipment *that have helped to maintain the integrity of the regional railnets and have made hinterland boundaries rigid.*[4]

Although the hinterland boundaries of each state railnet correspond largely to the various state borders, and state policies have to a large extent led to self-contained nets, this rigidity can be overstressed.

The issue has been confused in Australia by a number of factors. In the past, the railway systems of the eastern mainland states handled a considerable volume of traffic for adjacent border districts in other states. This tendency is not as marked at present, and the tonnage involved is proportionately smaller.

The situation in South Australia, for reasons partly geographical, partly historical, is very exceptional. A considerable portion of the state-owned mileage is 5′3″ gauge, and is linked with the Victorian system to the east. The Port Augusta–Oodnadatta railway was purchased from South Australia by the Commonwealth Government, when the latter took over the Northern Territory in 1911.[5] This line has now been extended to Alice Springs, Northern Territory; the Port Augusta to Marree section is standard guage (4′8½″) while the Marree–Alice Springs section is 3′6″ gauge. Thus an intrastate line was converted to an interstate line. A second Commonwealth line, the standard gauge Transcontinental, extends from Port Augusta to Kalgoorlie, Western Australia. The mining center at Broken Hill in western New South Wales is connected to a 3′6″ gauge line from Port Pirie. As South Australia's state railways include both 5′3″ and 3′6″ gauge lines, having connections across state borders, and as both are connected with interstate 4′8½″ Commonwealth lines, appropriate state railnet hinterlands are difficult to delimit.

All state railnet hinterlands are now complicated by road transport. This is particularly so in southern New South Wales,[6] an area with which I am very familiar. The case of the Riverina is treated in detail below. The same situation existed, and much the same sequence of events has occurred in Western Victoria and eastern South Australia, and in northwestern New South Wales and southern Queensland.

During the early years of railway development in eastern Australia, much of the traffic of the Riverina was oriented towards Melbourne.[7] There were two important reasons for this orientation. In New South Wales the railway did not reach the Riverina until 1878;[8] Melbourne was the nearest major city and therefore came to be regarded as the "natural" outlet for the Riverina.[9] Secondly, Melbourne financiers held many of the farming mort-

[1] The writer acknowledges valuable discussions on the subject of this note with Professor O. H. K. Spate and Dr. G. J. R. Linge, of the Department of Geography, Australian National University.

[2] Vol. 48, No. 4, pp. 352–74.

[3] *Ibid.*, pp. 360, 362.

[4] *Ibid.*, p. 362. Italics mine.

[5] *Commonwealth Yearbook*, No. 6 (Melbourne, 1913), pp. 1114–5.

[6] Referred to as the "Riverina."

[7] "Return to an Order No. 2 . . . ," Australian Federation Convention Proceedings, March, April, and May, 1897, in *Papers Presented to Parliament, Legislative Assembly of Victoria*, 1897, Vol. 2, Paper No. 25, pp. 1287–1476. A line from Melbourne to Echuca (on the Victoria–N.S.W. border) was opened for traffic in 1864, *Victorian Railways Report* (Melbourne, 1864–65), p. 11.

[8] *N.S.W. Railways Report* (Sydney, 1899–1900), Appendix 11, p. 25.

[9] Incidentally, this led to actual Victorian claims to the ownership of the Riverina.

gages of the area, and as a result of this, much of the trade and commerce was drawn southwards.

The vigorous railway-building program conducted by New South Wales in the late 1870's resulted in intense competition between this state and Victoria for the trade of the Riverina; this competition found its expression in cut-throat differential rates, offered by both states.[10] At the height of this struggle in the early 1890's, wool from Bourke and northwestern New South Wales was being carried over the Victorian section of the journey to Melbourne for up to sixty-five percent less than the price charged Victorian-grown wool travelling the same distance to Melbourne.[11]

Under the unfamiliar shadow of Federation, an attempt was made to rationalize the situation, and a temporary agreement was reached in 1905 between New South Wales, Victoria, and South Australia that no special rebates would be offered to attract the traffic of a border district.[12] A further agreement between New South Wales and Victoria in 1922 provided for the construction of four 5'3" lines in the Riverina, connecting with the Victorian system. Only two came to fruition, the Yarrawonga to Oaklands and Barnes to Barnald. A third 5'3" gauge line from Moama to Deniliquin was opened by a private company in 1876; it was resumed by New South Wales in 1923 and handed over to Victoria.

Even though some measure of agreement on the question of competitive rates was reached early in this century, extension of 5'3" lines into the Riverina in the 'twenties played some part in extending the railnet hinterland of Victoria beyond the borders of that state.

At present, the eastern mainland state railway systems cannot claim entire state areas as traffic hinterlands, despite the fact that, to date, little has been done about the break-of-gauge problem; the New South Wales 4'8½" system was linked with Brisbane in the 1930's, and a standard gauge line from Wodonga to Melbourne is at present under construction. Intersystem competition is not now the major factor in weakening the rigidity of state borders as railnet hinterland boundaries, although it does play a minor part.[13] Rather, road haulage operations, particularly since 1954 when state regulating legislation on interstate carriers[14] was declared invalid by the Privy Council,[15] have been directly responsible for both reducing and enlarging state railnet hinterlands in relation to state boundaries. Most border districts, and particularly the Riverina, now rely on road transport based on the capital city or large regional center of an adjacent state rather than, as earlier, on their state railway. Supporting evidence for this assertion as it applies to the Riverina is provided from a field enquiry,[16] and also from a preliminary statistical analysis of rail movements of goods to and from stations in southern New South Wales.[17] From a regression of inwards tons (Y) from all New South Wales origins, on population of station towns (X), residuals were plotted from the regression equation ($\log Y = -0.9428 + 0.9124 \log X$), on a map. With very few exceptions, Riverina stations received a far smaller proportion of inwards tons from New South Wales origins than one would expect on the basis of their populations. It seems highly likely from this analysis that the centers are being supplied from Victoria, either by rail from the Victorian origin to the

[10] See "Return to an Order . . . Differential Rates," *Votes and Proceedings, Legislative Assembly of N.S.W.*, 1888–89, Vol. 2, pp. 805–890 (1 Nov., 1888). Also, "Return to an Order No. 2 . . . ," in Australian Federation Convention Proceedings, *op. cit.*

[11] Maps (Exhibits) C and D, in "Return to an Order No. 2 . . . ," *ibid.*

[12] *Victorian Railway Report* (Melbourne, 1904–05), pp. 12–13; *N.S.W. Railways Report* (Sydney, 1904–05), p. 5.

[13] The Victorian Railways offer considerably lower rates for general merchandise to stations located on the Victorian–New South Wales border than to stations within Victorian territory. (Private Communication, Commercial Department, Victorian Railway Dept., July, 1959).

[14] *Votes and Proceedings, Legislative Assembly of N.S.W.*, 1930–31–32, Vol. 1, p. 203 (21 May, 1931). The legislation of N.S.W. and similar legislation in the other states, made it necessary for interstate carriers to obtain permits from the states through which they planned to operate; state transport departments used the permit system to protect their own railways, either by simply not granting a permit, or by charging disastrously high permit and registration fees.

[15] *Report of the (N.S.W.) Commissioner for Motor Transport* (Sydney, 1954–55), p. 16.

[16] Conducted by the writer in March, 1959.

[17] This preliminary statistical analysis is based on tonage figures from a five-day systematic random sample of the 261 week days of 1957–58. This initial study will be supplemented by a more complete enquiry based on a 29-day systematic random sample of the year July 1959–June 1960.

border at reduced rates and then by road transport or by road transport from the Victorian origin.

State railnet hinterlands have long since been modified by interstate rail competition. Attempts were made early in this century to improve irrational situations concerning border districts, but they were not entirely successful. The marked development of road transport in Australia in the last decade, aided after November 1954 by a legal decision against regulating legislation, again modified railnet hinterlands.

This note seeks only to enlarge on a small point of detail and is not meant to detract from the worth of Wallace's contribution.

ROBERT H. T. SMITH
Australian National University

ONE CHINESE VIEW OF THE "HYDRAULIC SOCIETY"

In keeping with Mr. Shabad's recent letter on "Non-Western Views of the 'Hydraulic Society'"[1] and his concluding reminder that Professor Wittfogel's basic theme had been sharply criticized by non-Westerners, I offer here a third comment. This was in an article by Professor Wu Ta-k'un, an economist now teaching at the People's University in Peking. The article was written in Oxford in 1951 when Professor Wu was returning from the United States to China.[2]

Wu does not criticize Wittfogel's thesis on ideological nor even primarily on economic grounds, but rather on archeological evidence of early bronze usage and on historical records of the first written references to canals and dykes long *after* the development of a despotic state system. Writing of the formation of the despotic state in China, Wu points out that in the Chinese Bronze Age of Shang and Western Chou (1450–772 B.C.), the country was a collection of hundreds of tribal states scattered out in the large drainage basins of the Yellow and the Yangtze rivers; they were not centrally clustered as along the Nile and the Fertile Crescent of Mesopotamia.

Within each tribal state, agriculture was carried on by village communes that owned land in common. Groups of communes were governed under "nobles" appointed by the ruler of the tribal state. These petty nobles soon entrusted the details of government to clerks who in turn "came to form a separate social class intermediate between the nobility and the peasantry."

Coming to the role of irrigation, Wu continues:

> The form of government based on this system was of course despotic; it was despotic because it was a bronze-using civilization, and the costly copper and tin, the only known metals, were a monopoly of the rulers. Its despotic character was accentuated by the development of artificial irrigation works, whose maintenance played a great part in the stability of any government. They cannot, however, be regarded as the *fons et origo* of despotism, since there is no evidence to suggest that any such works existed prior to the Chou dynasties. Even then, they differed from the irrigation works of the Near East. The rainfall of China is in most areas plentiful, and the arable areas of the river valleys much more extensive. The ancient oracle bone inscriptions [Shang, 1450–1050 B.C.] are full of references to rain and water, but have no words for canals or dykes, which were first constructed on any scale in the period of the Warring States (481–256 B.C.), when China was already passing into the Iron Age, long after the despotic state was firmly established. It is important to keep the role of irrigation in proper perspective, since an exaggerated emphasis on artificial irrigation underlies the theories of Dr. K. A. Wittfogel, which at present enjoy a considerable prestige in the United States, and may easily mislead students more familiar with Near Eastern than Chinese geography and climate.

That the development of irrigation works could not hold together this particular form of despotic government is brought out as Wu continues:

> This kind of economy [i.e., village communalism] tallies well with the so-called "Oriental," or "Asiatic," mode of production.[3] But it did not out-

[1] *Annals*, Association of American Geographers, Vol. 49, No. 3 (September 1959), pp. 324–325.

[2] Wu Ta-k'un, "An Interpretation of Chinese Economic History," *Past and Present*, Vol. 1, No. 1 (February 1952), pp. 1–12.

[3] Wu's footnote: "The term was first employed by Marx, in a number of scattered passages, of which the most important is the recently published manuscript

live the Chou dynasty, and cannot be held to characterize later periods of Chinese history. It did not survive because in the last centuries of the Chou dynasty, the period of the Warring States, iron began to come into use. The use of metal spread considerably. Better agricultural implements, including the animal-drawn plough, were invented. The economic centre of China was then in the north, the wheat-growing area. The invention of the animal-drawn plough extended cultivation, increased the crop yield, and so increased the population; new areas were brought under tillage, migration from one region to another became common, and trade developed. Metal currency, in small copper coins, first minted in 524 B.C., became popular, and a wealthy merchant and usurer class took shape. Mercantile capital began to disintegrate the tribal state and the village commune, for they stood in the way of new technical advances. A new economy and a new political system became necessary.

entitled 'Pre-capitalist Forms of Production' (*Vjestnik Drevnii Istorii*, 1940). The conceptions which Wittfogel developed from the term are vigorously challenged both by Marxists and by most Sinologists."

I believe that this whole controversy provides an open invitation to geographers—and especially political geographers—to move forward in the study of the relations between at least some of the aspects of the physical environment and political institutions. Bronze, water, control of the altiplano, malaria, ships' timber, cattle, large grain supply, pass routes —the list is very long.

THEODORE HERMAN
Colgate University

PROJECTION PITFALLS

In a recent issue of the *Annals*, R. L. Williams commented on the fallacy of ignoring basic principles of map projections when attempting to illustrate concepts of scale.[1] A similar "simplification" of the subject of map projections itself has, on at least one occasion, led to strange results. One such situation in which the distinction between geometric perspective projections and projections involving more complex mapping transformations was not emphasized is the following:

A young mathematician was instructed to prepare a computer program to transform latitude and longitude into rectangular coordinates on a Lambert Conformal Conic with two standard parallels for machine printing of information on a base map prepared on this projection. Map projections were explained to the young programmer by analogy to the simple geometric projections. Being an ingenious fellow, he drew a diagram and proceeded to derive equations for a gnomonic conic projection, secant at the requisite parallels. The computer program was prepared, and, due to the convergence between the two projections at the machine printing scale, everything went quite well for about two years. Then, as the area of mapping increased in distance from the standard parallels, errors became more and more obvious, finally greater than could be tolerated. Finding mistakes in a computer program cannot be appreciated by the uninitiated. Eventually three errors were discovered: (1) the program projection and the base map projection were not the same; (2) different earth radii were used in the machine program and in the drawing of the base maps; and (3) the program used only one scale factor, not dependent on the projection (Williams' point).

The results were, however, not all negative. It was found, for instance, that for a limited area an oblique stereographic projection is satisfactory for machine printing on a Lambert Conformal Conic base map. The stereographic projection is computationally simpler, while the Lambert map is easier to draw. All projections of course converge in this manner—the criterion must be ease of computation and accuracy requirements.

WALDO R. TOBLER
University of Washington

[1] Robert Lee Williams, "Map Projections, Linear Scale, and the Representative Fraction," *Annals*, Association of American Geographers, March 1959, p. 88.

THE SPACING OF RIVER TOWNS

Burghardt, in a recent article, "The Location of River towns in the Central Lowland of the United States,"[1] examines two questions similar to those posed by many geographers. First, why are the larger river towns on a particular bank of the river? Second, what spacing have these towns? The solution of the former requires isolating the significant causal factors in the location and growth of towns. In the latter, the requirement is the description of the geometric arrangement of a map distribution. In this note, this description is objectively provided by use of the "nearest neighbor" technique.

An example of the results obtained by the nearest neighbor technique is given in Table 1. The spacing of river towns in the Central Lowland is given in terms of both airline and river distances, and the following spatial characteristics are indicated. Along the Ohio and Missouri rivers, the spacing of towns is highly uniform, but the towns on the Mississippi River are slightly grouped. Using the confluence of the Ohio and Mississippi as the dividing line, the town spacing on the Lower Mississippi is completely random while on the Upper Mississippi it is grouped. The spacing of river towns in the Central Lowland is thus only slightly more uniform than the spacing in a random distribution.

TABLE 1.—SPACING OF RIVER TOWNS IN THE CENTRAL LOWLAND OF THE UNITED STATES

River	Number of river towns	Spacing[1]	Index of spacing[2]
Ohio	11	Highly uniform	.909
Missouri	7	Highly uniform	.857
Mississippi	17	Slightly grouped	.588
Lower Mississippi	6	Random	.667
Upper Mississippi	11	Grouped	.545

[1] The spacing in terms of both river and airline distance is given.

[2] This index is the proportion of points having reflexive first nearest neighbors.

The procedure used to obtain the above results may be used to describe any linear alignment of points. Examples of distributions suitable to this type of analysis are the spacing of river exits to the sea and the spacing of volcanoes on a fault line, the occurrence of a particular farm crop along a traverse line, or the threshold populations at which central place functions are found.[2]

Analysis of linear point distributions usually includes: (1) a statement of the distances between nearest objects, and (2) a general statement about the characteristics of the distribution. The latter contains subjective impressions derived from visual map analysis, and the statements are of the type: "The points are evenly spaced" or "They are grouped." This approach was used by Burghardt. Frequently, such visual analysis yields answers of the desired accuracy. Analytic techniques of map analysis which yield more precise statements may, however, be required —particularly when two or more distributions are compared.

A reflexive nearest neighbor method has been derived by Clark[3] which analyzes the spacing of points along a line. This method complements other nearest neighbor methods which analyze the pattern of points distributed within an area.[4]

The reflexive nearest neighbor method requires (1) a linear arrangement of points, and (2) a measure of the distance between points. The objects to be studied may be any abstract or concrete phenomena which may be comprehended as points, and have an ordering which includes an origin and a termination point. The measure of distance between points may be in any generalized unit, such as miles, inches, frequency counts, or any arbitrary scaling.

Given the distance between points, the steps of the procedure are:

(1) The points are arrayed in linear order from origin to termination, or from smallest to largest value.

[1] Andrew F. Burghardt, in *Annals*, Association of American Geographers, Vol. 49 (1959), pp. 305–323.

[2] This latter problem has been analyzed by nearest neighbor methods. See: Brian J. L. Berry and William L. Garrison, "The Functional Bases of the Central Place Hierarchy," *Economic Geography*, Vol. 34 (1958), pp. 145–154.

[3] Philip J. Clark, "Grouping in Spatial Distributions," *Science*, Vol. 123 (1956), pp. 123–125.

[4] Nearest neighbor procedures designed for the analysis of the pattern of points distributed within an area are thoroughly reviewed in P. Greig-Smith, *Quantitative Plant Ecology* (New York: The Academic Press, 1957).

(2) If not known, the distance between successive points is computed.

(3) The point nearest to each point is determined. This nearest neighbor relationship is conveniently indicated by drawing a directed arrow from each point to its nearest point (Table 2).

(4) Some of the directed arrows are paired indicating that the relationship of nearest neighbor is reflexive. The paired points are the nearest neighbors of their nearest neighbors. These points are counted.

(5) The number of points which have reflexive nearest neighbors is expressed as a proportion of the total number of points.

The reflexive nearest neighbor analysis may use only these nearest neighbor relations. A more thorough analysis of a linear point distribution requires, however, the evaluation of second, third, and more distant nearest neighbor relations. This evaluation is an extension of the above procedure and the additional steps are:

(6) The second nearest neighbor of each point is determined and is indicated by a directed arrow (Table 2).

(7) The number of points which are the second nearest neighbor of their second nearest neighbor are counted. These reflexive second nearest neighbors are indicated by paired arrows.

(8) The number of points which have reflexive second nearest neighbors is expressed as a proportion of the total number of points.

(9) The procedure outlined in steps (6) through (8) is repeated for third, fourth, and more distant nearest neighbors. The procedure ends when the researcher arbitrarily decides its continuation will yield no new information about the point distribution.

It is shown by Clark[5] that when the spacing between points is *random*, the proportion of points which have *n*th order reflexive nearest neighbors is equal to $(2/3)^n$. There is a *uniform* spacing of points when the proportion of points having *n*th order reflexive nearest neighbors is greater than $(2/3)^n$. The spacing of points is *grouped* when the proportion is less than $(2/3)^n$. The greater the deviation from $(2/3)^n$ the more pronounced is the grouping or uniformity. When all points are members of two reflexive nearest neighbor pairs, the spacing of points is completely uniform. Conversely, when only two points have reflexive nearest neighbors, the spacing of points is completely clustered.

The town spacing on the Mississippi as presented in Table 1 is an example of the nearest neighbor procedure, and the analysis was completed in less than thirty minutes.

The criteria used by Burghardt to select the river towns for his analysis are not clear. Accordingly, this analysis is arbitrarily limited to river towns of 20,000 or more inhabitants and only one such place from each Standard Metropolitan Area is included. The nearest neighbor procedure is, of course, unchanged if a more inclusive definition of a river town is adopted. The distance between towns was measured by both airline miles and river miles. However, by both distance measures

TABLE 2.—NEAREST NEIGHBOR ANALYSIS OF TOWN SPACING ON THE MISSISSIPPI RIVER

River town	Airline distance	Nearest neighbor	Second nearest neighbor	Third nearest neighbor
New Orleans				
	73			
Baton Rouge				
	76			
Natchez				
	62			
Vicksburg				
	74			
Greenville				
	132			
Memphis				
	137			
Cairo				
	123			
St. Louis				
	96			
Hannibal				
	16			
Quincy				
	63			
Burlington				
	57			
Davenport				
	30			
Clinton				
	53			
Dubuque				
	95			
La Crosse				
	25			
Winona				
	102			
Minneapolis				

[5] Clark, *op. cit.*, p. 124.

each town had the same first nearest neighbor; so the two results are almost identical. In Table 2 airline miles were used. The river towns were ordered by their location from the river mouth to its headwaters; if the reverse order were used the results would be unchanged.

The analysis of the first, second, and third nearest neighbor relations is shown in Table 2. The directed arrows indicate the nearest neighbor relations of the specified order, and paired arrows indicate reflexive nearest neighbors. The number of points which have reflexive nearest neighbors are obtained from Table 2. For example: (1) New Orleans and Baton Rouge are reflexive nearest neighbors; Natchez and Vicksburg also have reflexive nearest neighbors. Greenville and Memphis, however, do not have reflexive nearest neighbors. (2) Baton Rouge and Natchez are examples of points which have reflexive second nearest neighbors while New Orleans and Vicksburg are examples of points which do not have reflexive second nearest neighbors. (3) Baton Rouge, Natchez, Vicksburg, and Greenville are the only points which have reflexive third nearest neighbors.

There are 17 river towns on the Mississippi. Of these, ten have reflexive nearest neighbors, six have reflexive second nearest neighbors, and four have reflexive third nearest neighbors. The proportions of points which have first, second, and third nearest neighbors are, respectively: $10/17 = .588$, $6/17 = .353$, and $4/17 = .235$. In a random spacing of points, the proportions of points having reflexive first, second, and third nearest neighbors are: $2/3 = .667$, $(2/3)^2 = .444$, and $(2/3)^3 = .296$.

The spacing of river towns on the Mississippi is more grouped than random because the proportions for the river towns are all less than those occurring in a random distribution. This does not support Burghardt's assertion that "The larger river towns . . . reveal an interesting uniformity of spacing along the rivers."[6]

MICHAEL F. DACEY
University of Washington

[6] Burghardt, *op. cit.*, p. 322.

REVIEW ARTICLES

CHANGE IN REVIEW EDITOR

Readers of the *Annals* should note that a new Review Editor is listed on the inside covers of this issue. Dr. Marion E. Marts, Department of Geography, University of Washington, has agreed to take on this difficult assignment—an assignment served so well and with distinction by Dr. Norton Ginsburg. The two Review statements in this issue were prepared under the auspices of Dr. Ginsburg and additional material planned by him may appear on *Annals* pages. All new material for this feature—books and articles—are now the special concern of Dr. Marts, and related correspondence should be addressed to him.

WALTER M. KOLLMORGEN
Editor, *Annals*

COMPARATIVE STUDIES IN FRONTIER HISTORY

Nearly seven decades have passed since Frederick Jackson Turner (1861–1932) developed a new approach to American history, an approach which has come to be known as the frontier hypothesis or the Turner thesis.[1] In the intervening years a substantial part of the work of American historians has been devoted to analysis, criticism, and elaboration of Turner's views. Yet, there is little agreement that the main problems of frontier history have been solved. For every theory there is at least one counter theory, and for every generalization there are specific objections. In view of this state of discord, there would seem to be little justification for bringing the work of frontier historians to the attention of geographers. There is, however, one aspect of their work that deserves serious attention, and that is the growing body of comparative research. In this review attention will be directed to several recent attempts to compare the westward movement in American history with the advance of settlement in other parts of the world. "Frontier" will be used in the historian's sense to refer to the outer edge of settlement within a given area and not to a political boundary.[2]

TURNER AND THE AMERICAN FRONTIER

During the first half of the nineteenth century, American historians put great stress on the European and colonial origins of national institutions. The crises of the Civil War and the Reconstruction claimed major attention in later decades. Turner sought a fresh point of view. In 1893 he presented the now famous thesis that the distinctive features of American society could be explained by the existence of an area of free land, its continuous recession, and the advance of settlement toward the west. The advance of the frontier meant a steady movement away from the influence of Europe and a growth of independence along new lines. The frontier was a great "seedbed" for the growth of American democracy. Using a different metaphor, Turner described the frontier as a "safety-valve," which relieved poverty outside the West and on the frontier itself fostered economic equality. The "raw" environment of the frontier encouraged men to invent, to modify old ways, and to profit from contact with immigrants of different backgrounds. The frontiersman was a rugged individualist, but he learned to cooperate with his neighbors during militia musters, cabin-raisings, scow-launchings, harvest festivals, and logrollings. In short, the frontier was the line of most rapid and effective Americanization, the source of much that is distinctive in national character.

Another feature of Turner's thesis was his insistence that frontier life meant a "perennial rebirth" of society followed by steady growth along predetermined lines. America's first frontier was compounded of fishermen, fur-

[1] "The Significance of the Frontier in American History," *Annual Report of the American Historical Association for 1893* (Washington, D. C., 1894), pp. 199–227. Reprinted in F. J. Turner, *The Frontier in American History* (New York: Henry Holt, 1920 [reissued 1958]), pp. 1–38.

[2] See Fulmer Mood, "Notes on the History of the Word *Frontier*," *Agricultural History*, Vol. 22 (April, 1948), pp. 78–83, and the recent discussion of Ladis K. D. Kristof, "The Nature of Boundaries and Frontiers," *Annals*, Association of American Geographers, Vol. 49 (September 1959), pp. 269–82.

traders, miners, cattlemen, and farmers. As the frontier moved beyond the Alleghenies only the fishermen were left behind. In his address of 1893, Turner invited his listeners to "stand at the Cumberland Gap and watch the procession of civilization, marching single file —the buffalo following the trail to the salt springs, the Indian, the fur-trader and hunter, the cattle-raiser, the pioneer farmer—and the frontier has passed by. Stand at South Pass in the Rockies a century later and see the same procession with wider intervals between."[3] The vivid imagery of this passage helps to explain the persuasivenes of the thesis as a whole. Turner was well aware of the need of conscientious scrutiny of evidence, but the factual detail embodied in the frontier hypothesis was selected to illustrate a larger truth.

Until the 1930's few historians seriously questioned the frontier hypothesis. It was inevitable that such a formula should appeal to a people who felt instinctively that they had created more than they had inherited and that they owed little to the Old World. Another basis for the popularity of the thesis was its democratic character, for Turner presented American history as a creative act in which all had participated, rich and poor. The heritage of frontier lore conferred on Turner the authority of one who speaks from the distilled experience of his people. Long before Horatio Alger apotheosized the self-made man, every American boy knew in his heart that he could become some kind of pioneer.[4] It was ominous to be reminded that the frontier had reached the Pacific coast, for with that final advance much of the progressive element in American life seemed to have disappeared; but the American people could still hope to reach "technological frontiers."[5]

In the eyes of "scientific" historians, facts are intractable, and in any encounter the general idea (or ideal) must yield to the specific detail. Examined from this viewpoint, the strains of romanticism and nationalism in Turner's writings seemed contrary to the spirit of objectivity. The frontier thesis has often been condemned as a naive expression of environmental determinism. Equally fundamental is the criticism that the main currents of American history can only be explained by taking account of industrialization, urbanization, and other developments not directly related to the frontier. It is now generally acknowledged that the frontier was less attractive as a "safety-valve" than America's budding industries. Several scholars have complained that the frontier hypothesis does not give sufficient emphasis to the importance of the rail and steamship in accelerating the westward movement. In one of the more penetrating criticisms of Turner's writings, J. C. Malin rejects the frontier hypothesis on the grounds that it violates "the fundamental principles of social causation as the unique interaction of multiple causes."[6] The view of Turner's most severe critics is that his thesis is not an interpretation of the significance of the frontier, but merely a distorted perspective of American history as viewed from the frontier.

Included among the many criticisms of the frontier hypothesis are some telling objections by C. O. Sauer.[7] Particularly objectionable, in his view, is the notion that frontier settlement can be described in terms of an inevitable sequence. "No groups coming from different civilizations and animated by different social ideals have reacted to frontier life in identical fashion." Therefore, "the kind of frontier that develops is determined by the kind of people found on it." According to Sauer, the successive frontiers of American settlement should be described as "a series of secondary culture hearths, of different origin and composition." This argument is carried to its logical conclusion by Owen Lattimore, who suggests that Turner's preoccupation with what the frontier

[3] Turner, *The Frontier in American History*, p. 12.

[4] See Henry Nash Smith, *Virgin Land: The American West as Symbol and Myth* (Cambridge: Harvard University Press, 1950), pp. 250–60.

[5] For discussion of these points see Henry S. Commager, *The American Mind: An Interpretation of American Thought and Character Since the 1880's* (New Haven: Yale University Press, 1950 [Yale Paperbound, 1959]), pp. 293–309.

[6] James C. Malin, "Space and History: Reflections on the Closed-Space Doctrines of Turner and Mackinder and the Challenge of Those Ideas by the Air Age," *Agricultural History*, Vol. 18 (April and July 1944), pp. 65–74, 107–26, ref. to p. 65.

[7] Carl O. Sauer, "Historical Geography and the Western Frontier," in James F. Willard and Colin B. Goodykoontz, eds., *Trans-Mississippi West* (Boulder: University of Colorado Press, 1930), pp. 267–289, ref. to pp. 282–83.

did to society prevented him from seeing what society did to the frontier.[8]

What mechanisms perpetuated democratic institutions once the problems of frontier life had been resolved? According to a recent study by Elkins and McKitrick, the answer to this question should be sought in the petty capitalism of the small town.[9] In another recent study, D. M. Potter suggests that the availability of "free land" was merely one manifestation of material abundance and a rising standard of living.[10] In a much-criticized book, W. P. Webb, one of Turner's best-known students, describes the westward movement in the United States as but one part of a "World Frontier."[11]

It is not necessary to examine the frontier hypothesis and the debate that has centered on it at length.[12] For the purpose of this review it is sufficient to note that the conception of the frontier as a central theme in national history has been an enduring force in American historiography. Turner's thesis was bound to provoke controversy, for the data of history always appear in a context of theory, narration, and interpretation, and historians, of all scholars, are least inclined to agree on what constitutes a reliable foundation of fact. The specific criticisms directed against Turner do not refute his basic contention that the frontier, in all the vague meanings of the word, was a significant influence in American history. It is not likely that further debate will clarify basic issues. In his later years Turner himself shifted attention from the frontier, which he had described as an integrating force, to a study of the centrifugal forces evident in American sectionalism.[13]

THE FRONTIER IN COMPARATIVE VIEW

The principal failing of Turner, his followers, and most of his critics has been a neglect of comparative research. Without the perspective afforded by knowledge of developments in foreign areas, it is not possible to interpret the significance of the American frontier. A persuasive argument for comparative study was presented by Herbert Heaton in an address to the Economic History Association several years ago.[14] In a more recent essay, P. F. Sharp calls attention to the advantages of viewing American frontier history against the background of comparable developments within the British Common-

[8] Owen Lattimore, "The Frontier in History," *Relazioni del X Congresso Internazionale di Scienze Storiche*, Vol. I (Firenze: G. C. Sansoni, 1955), pp. 105–38, ref. to p. 136.

[9] Stanley M. Elkins and Eric L. McKitrick, "A Meaning for Turner's Frontier, Part I: Democracy in the Old Northwest," *Political Science Quarterly*, Vol. 69 (September 1954), pp. 321–53. The second part of this study (*Ibid.*, December 1954, pp. 565–602) deals with "The Southwest Frontier and New England."

[10] David M. Potter, *People of Plenty: Economic Abundance and the American Character* (Chicago: University of Chicago Press, 1954 [Phoenix paperback, 1958]), pp. 142–65.

[11] Walter Prescott Webb, *The Great Frontier* (Boston: Houghton Mifflin, 1952). His "frontier" (see Fig. 2, p. 350) includes all of North America, South America, Australia, New Zealand, and Africa south of the rain forest. He speaks of a 400-year "boom," now ended, when Europe grew rich from the "windfalls" of vast resources on the World Frontier. He describes Western Europe as the "Great Metropolis," organizing and exploiting its overseas frontier.

[12] For further discussion see Robert E. Riegel, "American Frontier Theory," *Journal of World History*, Vol. 3 (1956–1957), pp. 356–80. A balanced collection of criticisms can be seen in George Rogers Taylor, ed., *The Turner Thesis Concerning the Role of the Frontier in American History* (Rev. ed., Boston: D. C. Heath, 1956), vii and 109 pp. Bibliography. 6 × 9. $1.50. This collection includes articles by Avery Craven, an outstanding Turnerian, and George W. Pierson, perhaps the most influential critic of Turnerian points of view.

[13] See the collection of his essays published posthumously in *The Significance of Sections in American History* (New York: Henry Holt, 1932).

[14] Herbert Heaton, "Other Wests than Ours," *Tasks of Economic History*, Supplement 6 (1946) to *Journal of Economic History*, pp. 50–62. Heaton does not refer to the "pioneer settlement" studies initiated by Isaiah Bowman, e.g., *The Pioneer Fringe* (New York: American Geographical Society, 1931), *Pioneer Settlement* (New York: American Geographical Society, 1932), and *Limits of Land Settlement* (New York: Council on Foreign Relations, 1937). Perhaps this is a conscious omission, for students of frontier history and pioneer settlement have had different aims. The rationale of the frontier historians has been an attempt to interpret the influence of past frontiers on national institutions. Bowman and his associates were concerned chiefly with the practical problems of pioneer settlement in modern times. For a clear statement of Bowman's interests, see his essay on "Settlement by the Modern Pioneer" in Griffith Taylor, ed., *Geography in the Twentieth Century* (2nd ed., New York: Philosophical Library, 1953), pp. 248–66.

wealth.[15] An effective demonstration of the value of comparative study is found in Dietrich Gerhard's thoughtful re-examination of the Turner thesis based upon the different histories of the Canadian, Australian, South African, German, and Russian frontiers.[16] In still another recent essay, J. L. M. Gulley presents an elaborately documented study of the diffusion of Turnerian and neo-Turnerian ideas.[17]

In 1954 the University of Wisconsin sponsored a series of lectures under the title "Wisconsin Reconsiders the Frontier." Thirteen of these lectures have been published in a volume designed to place the frontier hypothesis in the perspective of time and place.[18] The range of topics considered in the volume—from "Roman Colonization and the Frontier Hypothesis" to "Mark Twain as an Interpreter of the Far West"—is too broad to form a coherent pattern of thought. The most original and hence most stimulating essays are those devoted to foreign frontiers.[19] The collection also includes an essay by Webb on his conception of a "World Frontier," and several papers on frontier settlement in the United States. The final chapter, "Backwash on the Frontier" by A. I. Hallowell, is an analysis of Indian contributions to American culture.

The aim of comparative study is to build a foundation for generalization that extends beyond the particular conditions found in a given area at a given time. Where and when should comparison be sought? The editors of *The Frontier in Perspective* sought "to reconstruct the frontier in the perspective of world history, to lay the numerous frontiers against the Turner hypothesis, to test its validity, and to search for valid elements in the non-Turnerian history areas."[20] With this observation as an introduction, it is not surprising that the volume lacks coherence.

It goes without saying that the establishment of objective standards of comparability is a necessary prerequisite of any comparative study. When settlement takes place during the same period and in similar environments, the advantages of comparison are obvious. As Jan Broek points out, "the Great Plains and the prairies of North America, the Pampas of South America, the Siberian and Australian steppes, and the African Veld were all drawn into the sphere of western culture in the nineteenth century. One does not have to be a geographic determinist to believe that a comparative study of the settlement of these grasslands would greatly enlarge our perspective."[21]

Similarities should also be evident in the relative numerical strength of the immigrant and aboriginal peoples. For example, the great numerical superiority of the American pioneer over the Indian facilitated the establishment of settlement patterns that were not feasible on the frontier of Spanish colonization in northern Mexico. In addition to relative numerical strength, important differences may be discerned in the relationships of immigrant and aboriginal peoples. One may speak of frontiers of *inclusion* (more properly *assimilation*), illustrated by Roman, Arab, and Spanish colonization, and frontiers of *exclusion*, illustrated by American, Canadian, Australian, and South African colonization.[22] Again, one

[15] Paul F. Sharp, "Three Frontiers: Some Comparative Studies of Canadian, American and Australian Settlement," *Pacific Historical Review*, Vol. 24 (November 1955), pp. 369–77.

[16] Dietrich Gerhard, "The Frontier in Comparative View," *Comparative Studies in Society and History*, Vol. 1 (March 1959), pp. 205–29.

[17] J. L. M. Gulley, "The Turnerian Frontier: A Study in the Migration of Ideas," *Tijdschrift voor Economische en Sociale Geografie*, Vol. 50 (March–April and May 1959), pp. 65–72, 81–91.

[18] Walker D. Wyman and Clifton B. Kroeber, eds., *The Frontier in Perspective* (Madison: University of Wisconsin Press, 1957), xx and 300 pp. Bibliography, index. 6½ × 9½. $5.50.

[19] Silvio Zavala, "The Frontiers of Hispanic America" (pp. 35–58); A. L. Burt, "If Turner Had Looked at Canada, Australia, and New Zealand When He Wrote about the West" (pp. 59–77); A. Lobanov-Rostovsky, "Russian Expansion in the Far East in the Light of the Turner Hypothesis" (pp. 79–94); and Eugene P. Boardman, "Chinese Mandarins and Western Traders: The Effect of the Frontier in Chinese History" (pp. 95–110).

[20] *Ibid.*, pp. xix–xx.

[21] Jan O. M. Broek, "The Relations between History and Geography," *Pacific Historical Review*, Vol. 10 (September 1941), pp. 321–25, ref. to p. 324. For an interesting example of the kind of study recommended by Broek, see Donald W. Meinig, "Colonization of Wheatlands: Some Australian and American Comparisons," *Australian Geographer*, Vol. 7 (August 1959), pp. 205–13.

[22] A full discussion of exclusive relationships can be seen in Archibald Grenfell Price, *White Settlers and Native Peoples: An Historical Study of Racial Contacts Between English-Speaking Whites and Aboriginal Peoples in the United States, Canada, Australia, and*

may speak of *static* and *dynamic* frontiers, depending upon whether colonization is or is not checked by environmental, technological, or human barriers.[23] China, to cite a complex example, has had a relatively dynamic frontier of inclusion in the south and a relatively static frontier of alternating inclusion and exclusion in the north.[24]

In addition to these general considerations, there is much to gain from awareness of the social and economic conditions prevalent on a given frontier. It is difficult, for example, to see any clear parallel between the westward movement in the United States and the advance of colonization in Latin America. The first areas to be colonized by the Spaniards were inhabited by sedentary farmers, the "peaceful" or "sensible" Indians (*indios de razón*). When the Spaniards moved beyond the Aztec and Inca territories, they encountered primitive Indians, either hunters and collectors or part-time farmers, who were more mobile and more difficult to subdue. The advance of the conquistadores into the more difficult areas did not result from a sizable European immigration, nor from a desire to till new land; it was encouraged by gold, silver, and missionary zeal. In the more peaceful and culturally advanced areas a hybrid society was formed based upon the acculturation of Indians and Europeans. The presence of a large mestizo element in the population of most of the Latin American countries is a clear reflection of the inclusive character of the colonial frontiers.[25]

In the few areas of Latin America that have experienced a permanent expansion of settlement in post-colonial time, the dominant theme has been one of intensification of land use rather than movement to the edge of "free land." As Preston James remarks, many of the South American frontiers represent hollow waves of exploitation followed by abandonment and population decline.[26] According to James, there are four main areas of durable frontier expansion: the highlands of Costa Rica, the highlands of Antioquia in Colombia, the central valley of Chile, and the three southern states of Brazil. But the large holdings in most of these areas, the predominance of a few staples, and the relatively discontinuous pattern of settlement do not resemble the westward movement in the United States. For example, on the coffee frontier of São Paulo hasty advance and bonanza production discouraged occupation of all but the most productive land.[27] Perhaps the closest approximation of a Turnerian frontier is that of Antioquia, where rural society is composed of small landholders and homesteaders in sharp contrast to the more prevalent latifundia.[28]

Historians have long been intrigued by the similarities seemingly evident in the *Drang nach Osten* and the westward movement in the United States. A generation ago one of America's leading medievalists suggested that "the line of the Elbe, Oder, and Vistula rivers as clearly demarked the eastward expansion of Germany as the 'fall line' of the Atlantic seaboard, the Alleghenies, and the Mississippi delimited the successive stages of American westward expansion." He also suggested that the "return to primitive conditions" on the American frontier was "just as true of the history of the German border [*sic*]," and that the stages of economic development had been identical on the two frontiers.[29]

New Zealand (Melbourne: Georgian House; Cambridge: Cambridge University Press, 1949).

[23] For fuller discussion of this distinction see Lattimore (*op. cit.*, p. 177). Kristof (*op. cit.*, p. 272) speaks of frontiers "as manifestations of *centrifugal* forces," in contrast to boundaries which indicate the "range and vigor of *centripetal* forces;" he also refers (p. 273) to the contrasting functions of frontier *integration* and boundary *separation*.

[24] For a detailed study of China's southern frontier, see Herold J. Wiens, *China's March toward the Tropics* (Hamden, Conn.: Shoestring Press, 1954). The northern frontier is described by Owen Lattimore, *Inner Asian Frontiers of China* (New York: American Geographical Society, 1940), and Wolfram Eberhard, *Conquerors and Rulers: Social Forces in Medieval China* (Leiden: E. J. Brill, 1952).

[25] For discussion of these points see the essay of Silvio Zavala in *The Frontier in Perspective*, and Philip W. Powell, *Soldiers, Indians, and Silver: The Northward Advance of New Spain, 1550–1600* (Berkeley: University of California Press, 1952).

[26] Preston E. James, *Latin America* (Rev. ed., New York: Odyssey Press, 1950), p. 7.

[27] See Robert S. Platt, "Coffee Plantations of Brazil: A Comparison of Occupance Patterns in Established and Frontier Areas," *Geographical Review*, Vol. 25 (April 1935), pp. 231–39.

[28] For a detailed study of this frontier see James J. Parsons, "Antioqueño Colonization in Western Colombia," *Ibero-Americana*, No. 32 (1949).

[29] James Westfall Thompson, *Economic and Social History of the Middle Ages (300–1300)* (New York: Century Co., 1928), pp. 517–18.

Many of these ideas have withstood the tests of critical review, but the underlying assumption, that the German and American immigrants shared a common experience, is now generally discredited.[30] The German colonists were not frontiersmen in the American sense of the word. Wherever they went they were subject to the authority of the church and the nobility. A substantial number of the immigrants were skilled artisans, and not a few were Flemings and Hollanders invited into the East to reclaim marshland. Moreover, the form of settlement almost everywhere was the village or hamlet, not the individual farmstead idealized in American literature. Nor did the German colonists move into "free land." Needless to say, there is no basis for a comparison of German relationships with the Slavs and American relationships with the Indians.

The great drift of Russian immigrants into Siberia, as D. W. Treadgold demonstrates in a recent book, more closely resembled the westward movement in the United States.[31] Both frontiers were dynamic and exclusive, and both moved ahead of roads and rails. There may even be some justification for describing the Siberian migration as a "safety-valve." The demand for fur, silver, and other products of Siberia led to the supplying of the natives with arms and liquor, thus creating what Turner described as a "trading frontier"; but the transition from trading to farming was slower than in the United States. Like their American counterparts, the Russian pioneers had to learn to accept the hazards of dry farming. Like the Canadians they had to learn to accept the limitations of the boreal environment. The first routes of migration in both regions followed the rivers, but the Siberian immigrants did not have to cross mountain barriers.

In other respects the Russian and American experiences were profoundly different. Between absolute monarchy and a republican form of government and between serfdom, however modified, and homesteading there is a chasm that no amount of neo-Turnerian generalization can bridge. The demographic patterns were notably different, since Russia experienced no substantial immigration from abroad. The Russians spent six hundred years getting to the Urals, and a hundred more moving from there to the Pacific coast, a much longer period of conquest than the Americans required. The slow movement of the Russian frontier is especially noteworthy, for immigration proceeded almost wholly into areas that were already under Tsarist control. In contrast, the more rapid American migration involved annexation and settlement of new territory. Some of the native Siberian peoples, especially those of the taiga, were as primitive and numerically weak as the American Indians; others, particularly the Muslim pastoralists, were difficult to dislodge. Indeed, in the thirteenth century the pattern of expansion reversed itself, and a substantial part of European Russia fell prey to Turco–Mongolian horsemen. In comparing the Russian and American migrations, A. Lobanov-Rostovsky puts stress on the fact that the Russian frontier ran into the Chinese frontier.[32] This "collision" seems real enough in modern time, but it must be remembered that the historic role of China's northern frontier was defensive. As Lattimore remarks, "nothing could be more static in conception than the Great Wall."[33]

Since most research in frontier history has been based upon interpretations of American developments, the issues just considered can be rephrased in a general question. Given the special circumstances of settlement history in the United States, where should one look for fruitful comparison? The answer suggested by the preceding discussion is that one should look to Canada, Australia, and South Africa.

[30] Cf. Gerhard, *op. cit.*, pp. 218–23.

[31] Donald W. Treadgold, *The Great Siberian Migration: Government and Peasant in Resettlement from Emancipation to the First World War* (Princeton: Princeton University Press, 1957), viii and 278 pp. Maps, bibliography, index. 6¼ × 9½. $5.00. See also his preliminary statement in "Russian Expansion in the Light of Turner's Study of the American Frontier," *Agricultural History*, Vol. 26 (October 1952), pp. 147–52.

[32] Lobanov-Rostovsky, *The Frontier in Perspective*, pp. 93–94.

[33] Lattimore, "The Frontier in History," p. 117. See also his discussion of Russian and Chinese colonization in "The New Political Geography of Inner Asia," *Geographical Journal*, Vol. 119 (March 1953), pp. 17–30, in which he calls attention to a historical influence that Lobanov-Rostovsky overlooks, namely, the presence of Mongol and Turco–Mongol "buffer zones" between the Russian and Chinese frontiers.

CANADA

In Canada, as in the United States, application of the frontier hypothesis meant rejection, at least in part, of previous attempts to interpret national history in a colonial setting. The first "school of thought" in Canadian historiography has been described as the "Britannic or Blood is Thicker than Water School."[34] In time, it became evident that the Canadian communities could not be described as mere exclaves of England and France. The Canadians had shared in the experience of driving back the wilderness. Their "West" had also been a source of transforming energy, pulling along the conservative "East." In short, the westward movement was North American, not just American in the narrow sense of the word.

One of the strongest statements of this point of view was presented in 1928 by W. N. Sage.[35] He described the settlement of Nova Scotia as a northern extension of the New England frontier; the Ohio Valley as a zone of conflict between the Quebec fur-trading frontier and the American agricultural frontier; and the settlement of the Prairie Provinces as an enterprise involving pioneers of both countries.[36]

The vogue of Turnerian interpretation was relatively brief, for in a country which had maintained many transatlantic connections, there could not be a strong assertion of separate growth in isolation from the rest of the world. Moreover, the environment, even when seen as a determinant, was specifically Canadian and not American in the broad sense of the word.[37] The "Appalachian barrier" was circumvented at the beginning of Canadian history when Champlain sailed up the St. Lawrence and founded the first settlement at Quebec rock.[38] The "frontier" of the Maritime Provinces was on the Grand Bank, not in the forest environment idealized by Turner. The most important barrier encountered during the early period of settlement was the Laurentian Shield, and its effect was to disrupt the continuity of the settlement frontier. During the eighteenth and most of the nineteenth centuries, rural colonization was restricted to the Maritime Provinces, the St. Lawrence Valley, and Southern Ontario. This restriction is clearly shown on the population distribution maps for 1851 and 1871 in the new *Atlas of Canada*.[39]

Effective settlement of the North American grassland was accomplished by the railroads. This generalization holds true on both sides of the boundary. However, the advance of the Canadian rails lagged behind the American lines. When the Union Pacific and Central Pacific were joined near Ogden, Utah, in 1869, Canadian surveyors were still searching for a route across the interior plains. The slow progress of the Canadian Pacific was of major importance, for the prior existence of an export economy discouraged colonists from moving ahead of transportation lines; nor did they outrun the machinery of parliamentary government. The Canadian West was never

[34] J. M. S. Careless, "Frontierism, Metropolitanism, and Canadian History," *Canadian Historical Review*, Vol. 35 (March 1954), pp. 1–21, ref. to p. 2.

[35] W. N. Sage, "Some Aspects of the Frontier in Canadian History," *Canadian Historical Association, Report of 1928*, pp. 62–72.

[36] The mingling of Canadians and Americans in the Old Northwest and the Prairie Provinces has been the subject of much research. See especially M. L. Hansen and J. B. Brebner, *The Mingling of the Canadian and American Peoples* (Toronto: Ryerson Press; New Haven: Yale University Press, 1940), and Fred Landon, *Western Ontario and the American Frontier* (Toronto: Ryerson Press; New Haven: Yale University Press, 1941). A. L. Burt (*The Frontier in Perspective*, pp. 68–72) emphasizes the role of American Loyalists in the settlement of Upper Canada (i.e., Ontario) after the Revolutionary war.

[37] For discussion of this point see Morris Zazlow, "The Frontier Hypothesis in Recent Canadian Historiography," *Canadian Historical Review*, Vol. 29 (June 1948), pp. 153–67.

[38] Cf. Reginald G. Trotter, "The Appalachian Barrier in Canadian History," *Canadian Historical Association, Report of 1939*, pp. 5–21, and Stanley D. Dodge, "The Frontier of New England in the Seventeenth and Eighteenth Centuries and Its Significance in American History," *Papers of the Michigan Academy of Science, Arts and Letters*, Vol. 28 (1942), pp. 435–39.

[39] *Atlas of Canada* (Ottawa: Department of Mines and Technical Surveys, Geographical Branch, 1957), Plate 46. In order to appreciate the significance of these maps, one must compare them with compilations for the same periods in the settlement history of the United States. For example, cf. Charles O. Paullin, *Atlas of the Historical Geography of the United States* (Washington, D. C.: Carnegie Institution, 1932), plates 76–79.

"wild" in the American sense of the word.[40]

Another point to be emphasized in any comparative study is that Canada suffered almost from the beginning of its history from the competition of its more richly endowed neighbor. As Heaton remarks, "Canada felt the effect of the United States in the attraction of immigrants to New York rather than to Montreal, in the emigration of her own native born, in the pull of the Erie Canal and then of the American railroads which wrecked her hopes of channeling the produce of the Middle West down the St. Lawrence, and in the competition that her infant industries had to face from rivals across the border."[41]

During the earliest period of North American colonization, French Canadians, above all the fur-traders, were the most adventurous frontiersmen. But the *coureurs de bois* were not representative citizens of New France. The great majority of the French Canadians were *habitants*, devoted to their narrow fields. Moreover, the patterns of land division and tenure were influenced by the seignorial system inherited from Old France.[42] The extent to which the Canadian system differed from that of France can be explained by two and perhaps only two facts: in Canada land was cheap and labor was dear. When overpopulation fostered restlessnes, the prospects of pioneer life held little appeal; the French Canadians preferred to move to New England or to their own industrial towns. In a pointed refutation of the frontier thesis, Mason Wade describes the unifying thread of French Canadian history as an "intense provincialism."[43]

Much of the credit for the development of durable interpretations of Canadian economic history belongs to Harold A. Innis (1894–1952), who demonstrated in many books and articles that the economic development of Canada should be approached from the standpoint of trade with other countries, France in the beginning, later Great Britain and the United States, and finally the Orient and the world generally.[44] Recognition of the vital role of trade stimulated interest in the history of transportation. By the mid 1930's most historians belonged to what Careless describes as the "Laurentian School."[45] The main tenet of this "school" was that the St. Lawrence and its tributaries became the basis of an extensive communication system around which Canada itself took shape.

Since interest in transportation routes presupposes interest in their foci, the "Laurentian School" quickly evolved into a "Metropolitan School." The metropolitan orientation is most explicit in D. C. Masters' study of Toronto, in which he traces the rise of the city to a position of dominance over Ontario, and describes its competition with Montreal for control of a broader Canadian hinterland.[46] The emphasis on the economic power wielded by cities is especially appropriate in Canada, where the major routes converge on Montreal, the national metropolis, Vancouver, the capital of the Far West, and Toronto, the communications hub of wealthy Southern Ontario.[47] The functioning of these cities may do more to explain the course of Canadian settlement than the frontier theme. For example, the best perspective of the fur-trade is gained from the entrepôts of Quebec. The organizing functions of the metropolis are even more clearly evident on the lumbering and mining frontiers. The building of the Canadian Pacific railroad far ahead of settlement is another illustration of the influence of urban

[40] For a full account of the history of settlement in the interior plains, see Arthur S. Morton and Chester Martin, *History of Prairie Settlement and "Dominion Lands" Policy*, Vol. 2 of W. A. Mackintosh and W. L. G. Joerg, eds., *Canadian Frontiers of Settlement* (9 vols.; Toronto: Macmillan, 1934–1940).

[41] Heaton, *op. cit.*, p. 58.

[42] E. R. Adair, "The French Canadian Seigneury," *Canadian Historical Review*, Vol. 35 (September 1954), pp. 187–207.

[43] Mason Wade, *The French Canadians, 1760–1945* (London and Toronto: Macmillan, 1955), p. vii.

[44] See the posthumous edition of his most influential articles in H. A. Innis, *Essays in Canadian Economic History* (Toronto: University of Toronto Press, 1956).

[45] Careless, *op. cit.*, pp. 14–16. The basic ideas of the "Laurentian School" are set out in Donald G. Creighton, *The Commercial Empire of the St. Lawrence* (Toronto: Ryerson Press; New Haven: Yale University Press, 1937).

[46] Donald C. Masters, *The Rise of Toronto, 1850–1890* (Toronto: University of Toronto Press, 1947).

[47] In his development of this theme, Careless, *op. cit.*, p. 17, gives some attention to the concept of an urban hierarchy. "The metropolitan relationship," he notes, "is a chain, almost a feudal chain of vassalage, wherein one city may stand tributary to a bigger center and yet be a metropolis of a sizable region of its own."

business interests. In time, if not at present, Edmonton's position with respect to the Canadian Northwest may be comparable to Seattle's role as the "regional capital of Alaska."[48] Metropolitanism figures prominently in the latest general treatise in Canadian economic history, in which the authors describe the central focus of their work as an attempt to determine "the part which business organizations, big and small, working in cooperation with government, have played in creating a national economy."[49]

AUSTRALIA

Students of Australian settlement were slow to accept the challenge of the frontier hypothesis, but when they did the American West seemed remarkably like their own "Outback." In 1940 W. K. Hancock described the advance of Australian settlement in language strongly reminiscent of Turner:

> There is a famous gap in the range of the Blue Mountains, that wall of rock and scrub which for a quarter of a century hemmed in this colony of New South Wales within the coastal plain. Stand at this gap and watch the frontiers following each other westward—the squatters' frontier which filled the western plains with sheep and laid the foundations of Australia's economy, the miner's frontier which brought Australia population and made her a radical democracy, the farmers' frontier which gradually and painfully tested and proved the controls of Australia's soil and climate. Stand a few hundred miles further west on the Darling River, and see what these controls have done to the frontier. The farmers have dropped out of the westward-moving procession, beaten by aridity. Only the pastoralists and prospectors pass on. In the west centre of the continent, aridity has beaten even the pastoralists. On the fringe of a dynamic society there are left only a few straggling prospectors and curious anthropologists, infrequent invaders of the aboriginal reserves.[50]

Here is the essence of the Australian reaction to the frontier theme. The basic ideas of the frontier hypothesis are endorsed, but not without recognition of the particular influences of the Australian environment. The history of Australian settlement has been in the main the story of a people inhabiting relatively narrow coastal belts in the eastern and southeastern parts of the continent, and a less thickly populated strip in the southwest. The dry heart of the continent can readily be compared with the American Southwest, but the Australian pioneer enjoyed no counterpart of the rich lands located between the Alleghenies and the Great Plains. A character in one of Henry Lawson's short stories describes Australia as "a big, thirsty, hungry wilderness, with one or two cities for the convenience of foreign speculators."[51] This appraisal seems unjust today, but Griffith Taylor's distinction between "Economic Australia" and "Empty Australia" still holds true.[52] The historical significance of the hundredth meridian in the United States and Goyder's line of "safe settlement" in southern Australia are remarkably similar.

The applicability of the frontier hypothesis in Australian history is subjected to rigorous tests in a recent study by H. C. Allen, who describes his task as an attempt "to study the history of man in the environment of two untamed lands of continental extent."[53] He considers the temporal relationships of the two histories, compares the two environments and the peoples environed, contrasts Australian and American patterns of pioneer settlement, and in a stimulating final chapter reappraises the frontier thesis in the light of the Australian experience.

As might be expected Allen's conclusions justify the essential Turnerian doctrine: the vital modifying effect of the open frontier. He concludes, again not surprisingly, that the notion of absolute determinism is absurd, "for

---

[48] William R. Siddall, "Seattle: Regional Capital of Alaska," *Annals*, Association of American Geographers, Vol. 47 (September 1957), pp. 277–84.

[49] W. T. Easterbrook and Hugh G. J. Aitken, *Canadian Economic History* (Toronto: Macmillan, 1958), viii and 606 pp. Maps, bibliography, index. 6¼ × 9¼. $6.50. The third part of the book, Canada's "Transcontinental Economy," is most relevant to the theme of this review.

[50] W. K. Hancock, *Problems of Economic Policy, 1918–1939*, Vol. 11, Part 1 of *Survey of British Commonwealth Affairs* (London: Oxford University Press, 1940), p. 5.

[51] Lyle Blair, ed., *The Selected Works of Henry Lawson* (East Lansing: Michigan State University Press, 1957), p. 60.

[52] Griffith Taylor, *Australia: A Study of Warm Environments and Their Effect on British Settlement* (5th ed., London: Methuen, 1949), pp. 4–7.

[53] H. C. Allen, *Bush and Backwoods: A Comparison of the Frontier in Australia and the United States* (East Lansing: Michigan State University Press, 1959), xv and 153 pp. Bibliography, index. 5½ × 8¼. $3.50. See also the earlier discussion of Fred Alexander, *Moving Frontiers: An American Theme and Its Application to Australian History* (Melbourne: Melbourne University Press, 1947).

what men are and what they bring with them, both consciously and unconsciously, when they come to the frontier, have far too great an effect upon their development."[54] What kind of men came to the Australian frontier? The first Outbackers were wealthy sheep-ranchers with a wage-earning personnel largely formed of ex-convicts. The Australian frontier thus started, as one author puts it, as a "big man's frontier," in contrast to the American "homesteader's frontier."[55] Thanks to the cooperation of the bankers, the Australian pastoralists were able to occupy the best land and discourage settlement by small farmers. The difficulties of would-be farmers were aggravated further by the fact that Australia did not have an effective executive or legislative authority until after the six colonies were federated in 1901. Land reform, stimulated by the clamor of a hundred thousand ex-miners, was not as encouraging as the American Homestead Act, for in addition to the terms of residence and improvement, the Australian settler had to pay.

The persistence of the pastoral oligarchy can be traced to Australia's imperial ties, for British capitalists were more interested in wool for the Yorkshire textile mills than in the successful settlement of small farmers. Moreover, a substantial part of Australia was better suited to extensive grazing than to any known combination of crops. Vast open spaces and a meager supply of labor encouraged the shepherd rather than the yeoman farmer. The typical Australian frontiersman in the last century was a wage-worker who did not, usually, expect to be anything else.

Until 1880 the American census reports referred to a frontier *line*. In Australia settlement fanned out from six points scattered far apart on the coast. Since coastal shipping could handle most of the interstate traffic, the progress of the railroads was slow. Isolation encouraged sectionalism;[56] and one of the results of sectionalism was the use of three widths of track, a problem that has defied plans for a unified railroad system. The meager development of roads and rails is especially significant in view of the absence of navigable rivers. As Allen remarks, "Old Man River is not a conceivable figure in Australian folklore."[57]

One of the points stressed by Turner was that the frontier was the most effective agent of Americanization. Was it the most effective agent of Australianization? Perhaps it was at first, at least until pastoral ascendancy was checked by the gold rush. But urbanization was already well advanced by this time, and as an ever larger proportion of Australian immigrants, as well as native born, came to reside in the great coastal cities, the importance of the Outback came to be more symbolic than real. Australian historians, like their Canadian colleagues, have gradually shifted from an agrarian to a metropolitan interpretation of national institutions. The metropolitan orientation is especially prominent in George Nadel's study of the political and social history of New South Wales.[58] Nevertheless, it seems to be true, as Allen remarks, that "what a people believe themselves to be is often as important in determining their actions as what they are."[59] In another new book, similar in scope to Nadel's work, Russel Ward argues that "a specifically Australian outlook grew up first and most clearly among the bush workers in the pastoral industry, and that this group has had an influence completely disproportionate to its numerical and economic strength on the attitudes of the whole Australian community."[60] It cannot be denied that frontier settlements and indeed a frontier spirit are still to be found in the tropical environment of northern Australia.

---

[54] Allen, *op. cit.*, p. 114.

[55] Brian Fitzpatrick, "The Big Man's Frontier and Australian Farming," *Agricultural History*, Vol. 21 (January 1947), pp. 8–12. This generalization also applies to the early stages of settlement in New Zealand. See Peter J. Coleman, "The New Zealand Frontier and the Turner Thesis," *Pacific Historical Review*, Vol. 27 (August 1958), pp. 221–37.

[56] See K. A. Mackirdy, "Conflict of Loyalties: The Problem of Assimilating the Far Wests into the Canadian and Australian Federations," *Canadian Historical Review*, Vol. 32 (December 1951), pp. 337–55.

[57] Allen, *op. cit.*, p. 9.

[58] George Nadel, *Australia's Colonial Culture: Ideas, Men and Institutions in Mid-Nineteenth Century Eastern Australia* (Melbourne: F. W. Cheshire; London: Angus and Robertson, 1957).

[59] Allen, *op. cit.*, p. 56.

[60] Russel Ward, *The Australian Legend* (Melbourne and London: Oxford University Press, 1958), ref. to p. v.

SOUTH AFRICA

The Great Trek of the Boers is usually described as a withdrawal from civilization, a concerted effort to reduce contacts with the outside world. The first migration began in 1835; it took the *Voortrekkers* out of the Cape Colony, one group going to Natal, one to the valley of the Vaal, and another as far as Delagoa Bay. The second movement began in 1843, the year of the British occupation of Natal. This occupation, followed by the annexation of Transorgania in 1848, led to movement over the Drakensberg and the Vaal into what was to become the South African Republic.

At least two motives contributed to the *Voortrekker* movement. The first was a desire to seek new employment away from the area controlled by the Cape Company. The Boers were producing large families, and in the Cape market itself supply had outstripped demand. The second motive was the passion for independence which led to Afrikaner nationalism. The events of the Trek, like those of most of the world's frontier movements, have passed into legend. The Trek came to be seen as the birth of a nation, as an Exodus, with Natal as the Promised Land and the Cape Colony as the Land of Pharaoh.

The beginnings of the *Voortrekker* movement can be traced to the Hottentot cattle trade. As the Hottentots grew shy and animals became scarce, expeditions went farther afield. As population pressure increased within the colony, pastoralists began to roam over unoccupied Crown Land and then over land that had not yet been claimed. In addition to the general fanning out of the Boer population, there were also seasonal migrations and unplanned flights in times of drought. Finally there were the organized treks, incorporating shepherds and farmers, and all the paraphernalia necessary to establish a relatively self-sufficient life.

There were no natural barriers to retard the migration, especially after it reached the veld; but in the middle of the eighteenth century the Boers ran up against another and numerically superior movement, the great southward drift of the Bantu. During the next three-quarters of a century there were no fewer than eight Kaffir wars, and these conflicts were only highlights of incessant strife. Moreover, the farther inland the Boers trekked, the greater the difficulty they experienced in marketing their goods.

With these essential facts in mind it is possible to draw some comparisons between the South African and American frontiers. Both were relatively continuous movements, and both ran ahead of roads and rails. The succession of livelihood was basically similar, although pastoral activity was more prominent and more enduring on the South African frontier. The data of comparative study suggest that the *Voortrekker* movement represented a lessening of contact with the outside world. In contrast, the Australian and Canadian frontiers were pushed forward by men eager to produce for a distant market.

Part of this interpretation is challenged in a recent publication of the Stanford Food Research Institute. In it, S. D. Neumark argues that the essential causes of the migration should be sought not only in the conditions prevalent on the frontier, but also in the economic development of South Africa as a whole.[61] He objects to the characterization of the Trek as a self-sufficient movement and refers instead to a frontier exchange economy based upon the barter or sale of livestock. According to Neumark, the *Voortrekkers* were never self-sufficient in the strict sense of the word. Even the most remote settlements were visited by itinerant traders. The demand for tea, sugar, and cloth kept the Boers at least marginally within the European consumer group. Moreover, the Boers were obliged to obtain firearms, powder, shot, wagons, and the other things that insured their military and technological predominance over the Bantu. In exchange they offered livestock, hides, horns, sheep-fat, tallow, and other products of the frontier. Neumark suggests that "even if the frontiersmen were 99 per cent self-sufficient, it was the 1 per cent that tipped the scale, for it constituted the minimum factor in the frontier economy."[62]

The validity of this interpretation, as W. K. Hancock points out in an extended review, depends upon the meaning that is assigned to

[61] S. Daniel Neumark, *The South African Frontier: Economic Influences, 1652–1836* (Stanford, Calif.: Stanford University Press, 1957), viii and 196 pp. Maps, bibliography, index, tables. 6¼ × 9¼. $5.00.

[62] *Ibid.*, p. 4.

"self-sufficiency."[63] According to Neumark's definition, the Hottentot and the Bantu might also be classified as members of a market-bound exchange economy. It would be unfortunate if the semantic aspects of this discussion were allowed to obscure important historical issues.

SOME CONCLUSIONS

The results of recent comparative studies indicate that there is much to compare and also much to contrast on the world's frontiers. In the first place, basic historical differences have to be emphasized. The American, Canadian, Australian, and South African frontiers were formed during a period of accelerated economic and social evolution. This fact distinguishes them from the German and Russian migrations which were influenced by feudalism. The characteristics of the Latin American frontiers reflect the numerical weakness of the conquistadores, the process of acculturation encouraged by that weakness, and the fact that Spanish colonists were not interested primarily in the cultivation of new land.

The relationships between immigrant and aboriginal peoples varies from extensive assimilation in Latin America to absolute extermination in Tasmania and near extermination in the United States. The relatively unimpeded advance of the Australian frontier contrasts with the bitter conflicts experienced during the early stages of colonization in South Africa. The advances of the Anglo-American, Latin American, and Russian frontiers were characterized at various times by peaceful penetration and violent conflict. The drift of the Germans into the Slavic lands seems to have been relatively uneventful, except, of course, during the crusades of the Teutonic Knights.

Environmental differences influenced the direction and rate of movement of the several frontiers. The St. Lawrence River enabled the first Canadian colonists to move into the heart of the continent, but the continuation of that movement was blocked by the Pre-Cambrian Shield. The simultaneous advance of Australian settlement from widely separated points on the coast presents a picture quite unlike the advance of the American frontier. The *Voortrekkers* enjoyed more favorable circumstances for a continuous advance, but the absence of navigable rivers impeded their communication with the outside world. The great, north-flowing rivers of Siberia did not equal the opportunities which the Mississippi and its tributaries offered to the American pioneer.

One of the main points of the Turner thesis is the claim that frontier movement and economic development were coincident. In Australia and South Africa the indigenous peoples offered little for trade, whereas in Canada and Siberia the fur-traders were the first and most adventurous frontiersmen. The early conflicts between pastoralists and farmers in the American West reappear in Australia, New Zealand, and to a lesser extent in Canada. In each of these countries legislation favorable to homesteading was encouraged by the agitation of ex-miners. It is difficult to trace an economic succession on the German frontiers, for nobles, peasants, merchants, and craftsmen often moved in organized groups. The pattern of succession in Latin America is obscured by the fact that the first colonists were drawn by missionary zeal or lured by gold. In modern time most of the Latin American frontiers have been scenes of highly specialized production for international markets.

The most challenging feature of Turner's thesis was his assertion that the frontier was a major influence in the formation of national institutions. The evidence drawn from other parts of the world neither confirms nor denies this claim. Indeed, comparative study has made no major contribution to this aspect of the Turner controversy; nor could it, for in the study of "national character," a vague concept at best, the historian quickly becomes entangled in a maze of multiple causes and effects.

In addition to these general observations, some critical conclusions can be drawn from this extended review. It seems clear that little can be expected from comparative study unless research proceeds in a more systematic manner. To speak of an idealized Australian or South African frontier and then to compare it with the American frontier is to beg important questions. It would be more rewarding to

[63] W. K. Hancock, *"Trek," Economic History Review*, Second Series, Vol. 10 (April 1958), pp. 331–39.

compare resource appraisal and technology, or, if a more general framework is desired, to compare the environments of the three frontiers. Discussion of the frontier "experience" has little meaning when the economic and environmental conditions of that experience are only vaguely recognized. In this connection it must be remarked that only one of the recent comparative studies, Allen's *Bush and Backwoods*, deals with the frontier environment in reasonably explicit terms. A failing common to all but one of the comparative studies, Neumark's *South African Frontier*, is the absence of a functional classification of settlements.[64] Needless to say, there is little to be gained from a comparison of single-family farmsteads and mining camps; yet such "comparisons" are inevitable when different types of settlement and different modes of livelihood are subsumed under "frontier." It is not the lack of precise data as such that is deplored, but the impossibility of making a functional assessment of any custom without some knowledge of who, among whom and in what context, indulges in it. W. R. Mead's recent study of the settlement frontier in Finland, a Thünen-type analysis, sets admirable standards of precise definition and accurate delimitation.[65]

These critical remarks are not intended to detract from the considerable heuristic value of the several studies reviewed here. If the frontier fails to emerge as an objective phenomenon, then it may at least be described as a research theme. The work of the frontier historians impinges upon the traditional interests of the geographer, for in their research, as in his, the principal variables are man and land. The fact that historians have not dealt adequately with such topics as settlement morphology, crop ecology, and resource management should stimulate geographers to make further contributions to the frontier theme.

MARVIN W. MIKESELL
University of Chicago

[64] For interesting examples of such classifications see Sauer, *op. cit.*, pp. 283–89, and James G. Leyburn, *Frontier Folkways* (New Haven: Yale University Press, 1935), pp. 5–6 and *passim*.

[65] W. R. Mead, "Frontier Themes in Finland," *Geography*, Vol. 44 (July 1959), pp. 145–56. See also his *Economic Geography of the Scandinavian States and Finland* (London: University of London Press, 1957).

VEGETATION MAPPING IN AFRICA

For years various governments have encouraged the scientific exploration of the African areas under their jurisdiction. In a number of instances this has included a careful stock-taking of available resources including all types of vegetation. It is very much to the credit of many European scientists that vegetation maps have been recognized as valuable instruments in preparing inventories and as tools for more efficient land use. Although this type of technical information is not equally appreciated in all parts of Africa, there are now few regions in that continent for which no vegetation maps are available. This paper will report on the progress in mapping the vegetation of Africa. Such a report brings the reader up-to-date in this field, and, more important, may reveal a number of problems which now can be attacked with a reasonable hope of finding useful solutions. Not all vegetation maps of Africa will be discussed, of course. The purpose of the paper is to show through examples what has been done, in what respects the achievements represent an advance in techniques and in usefulness, and how geographical and other research may benefit from these accomplishments. The evolution of vegetation mapping in Africa may be likened to a play in two acts: the first act reaching to the time of World War II and the second act comprising the postwar period.

THE FIRST PERIOD

The first period opened with a flourish in 1923, when Homer L. Shantz presented his well-known map of Africa at the scale of 1:10,000,000.[1] Never before had a vegetation map been published at so large a scale, in such detail, and for so large an area. The map was an achievement of first magnitude not only because of its size and detail, but also because

[1] H. L. Shantz, "Vegetation Map of Africa," 1:10,000,000, in H. L. Shantz and C. F. Marbut, *Vegetation Types and Soils of Africa* (New York: American Geographical Society, 1923).

of the careful planning and organization of its content. It is true that Shantz's map was not the first vegetation map ever made of Africa or any of its parts. Such maps had been published in textbooks, journals and atlases over a period of many years, though usually on a very small scale. Engler's excellent vegetation maps of the German colonies were particularly notable,[2] and, long before these, the vegetation maps of Tenerife by Meyer and of the Upper Nile countries by de Martonne had attracted wide attention.[3] But such achievements may rather be referred to as the overture, which indeed was not without its distinct *Leitmotiv*, heralding future developments.

The vegetation map by Shantz deserves attention because for the first time the vegetation of the entire continent was subjected to scrutiny all at once; data organized systematically and presented on a map of relatively large scale made manifest, with one stroke, the pattern and extent of all the major ecological regions of Africa. Harshberger had made a similar attempt for North America, but his map was limited to book-page size and was so generalized that it was not at all in the same class with Shantz's map of Africa.[4] That map made it possible to describe any area of Africa as part of certain vegetation regions, thereby implying significant features especially with regard to the physical character of the area and the potential development of its land use.

Shantz describes the vegetation of Africa as formations, using the definition by Flahaut and Schröter as adopted by the International Botanical Congress at Brussels in 1910. This means that the various types of vegetation shown on the map are all physiognomic types. Terms like "mangrove" or "acacia—tall grass savanna" may seem to be exceptions to the rule; but this is largely an illusion because such terms can be and are used physiognomically in spite of the generic names. The term "mangrove," for instance, at once produces in the mind of the reader a picture of broadleaf evergreen trees on stilts along muddy tropical tide-water shores. This physiognomic approach may be considered natural in view of the general ignorance of the African flora at that time, but Shantz realized that physiognomic distinctions are often equivalent if not superior to floristic data for indicating environmental conditions, especially on small-scale vegetation maps. This has been well established many times since Shantz published his map, although there are many botanists, even today, who view the physiognomic approach as superficial or primitive. Shantz followed the only way open to him. It was not only not primitive, it turned out to be quite the most intelligent way, too. The authors of even the very latest and most modern map of Africa (see below) insist on using a physiognomic approach which in character differs little from the method Shantz employed over a third of a century earlier.

Shantz was an apostle of applied science, and in the book on the vegetation of Africa which he published as a supplement to his vegetation map he constantly sought to relate the various types of vegetation to climate, soils, and land use. This forced him to pay a great deal of attention to terminology because on small-scale maps it is easy to use terms which are either cryptic or altogether useless. Shantz could neither tolerate nor afford this, and his clear descriptive terms set examples that might well have been followed by several of the later authors. Because of Shantz's practical turn of mind the vegetation units on his map are far from academic and here, perhaps, lies the reason why his vegetation map was such an immediate success and retained its value for so long. Here, too, is the explanation of the fact that so many geographers, especially students of Africa, have adopted Shantz's terminology *in toto* and use it to the present day. In fact, Shantz, the botanist, was a geographer at heart, as is well demonstrated by his publications and his membership in geographical societies. Perhaps it is the

[2] A. Engler, "Vegetationskarte von Deutsch-Ostafrika," 1:6,000,000, "Vegetationskarte von Deutsch-Südwestafrika," 1:6,000,000, "Vegetationskarte von Kamerun," 1:6,000,000, and "Vegetationskarte von Togo," 1:2,500,000, in *Die Pflanzenwelt Afrikas* (Leipzig: Engelmann Verlag, 1910).

[3] Hans Meyer, "Die natürlichen Vegetationsformationen auf Tenerife," 1:510,000, in *Beiträge zur Kenntnis der Vegetation der Canarischen Inseln*, Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition Valdivia (1898–1899); Emmanuel de Martonne, "Carte des formes de la vie végétale et animale dans le Haut Nil," 1:6,000,000, *Annales de Géographie* (1896), plate VIII.

[4] John W. Harshberger, "The Phytogeographic Areas, Districts and Regions of North America," 1:40,000,000, in *Phytogeographic Survey of North America* (Leipzig: Engelmann Verlag, 1910).

geographers who benefited most from Shantz's vegetation map of Africa for, to them at least, it permitted a regionalization of the continent which was simple, natural, and extremely useful.

There are a number of later vegetation maps of Africa, but it is not difficult to detect that the authors consulted the Shantz map and reproduced more or less modified versions of it. The model was there; no other existing map could be demonstrated to be superior. As a result, Shantz's work was for many years the basis of most small-scale vegetation maps of Africa.

Shantz's vegetation map of Africa satisfied the need for a continent-wide vegetation map for a long time, and no other important vegetation map of Africa was published for many years. However, interest was aroused. While few people had the opportunity to travel over all of Africa, many did become familiar with the vegetation of a part of the continent. The developments which followed the publication of Shantz's vegetation map found expression in a steadily growing number of vegetation maps of individual regions, often of some political division. Engler's example for the German colonies and Shantz's stimulus resulted in vegetation maps of several of the other European dependencies, although these colonies were not natural regions, and the vegetation boundaries and the political borders did not coincide anywhere. It was now feasible to make vegetation maps of different countries where different authors used different terminologies, and even if these countries were not contiguous, it was possible to correlate the major vegetation types of the various maps on the basis of Shantz's comprehensive pioneering work. Shantz's map was, therefore, not simply a valuable map in itself but contributed materially to the value of other vegetation maps by revealing the continent-wide affinities of the vegetation types shown in limited regions.

The regional maps usually were quite independent of Shantz's work, and most authors limited themselves to one region (unlike Engler). Many of these post-Shantz regional vegetation maps therefore show a high degree of individualism. They were, of course, done on a large scale and hence showed greater detail. This necessitated new terms, and gradually the physiognomic approach became enriched with floristic terms. However, the use of generic and specific names differed from that of Shantz. Rather than being disguised physiognomic terms, these names were now employed to render vegetational descriptions more precise and more detailed. It began to make a difference whether the dominant genus in the herbaceous communities of the savannas was *Pennisetum, Themeda, Imperata*, or something else.

More and more vegetation maps became available as the information accumulated, but a large proportion showed little progress. Their legends remained broad, and tropical rain forest, savanna, etc., remained standard expressions. The maps which indicated progress did so mainly by giving more detail and by adding floristic terms to the physiognomic ones, but their organization was often confused and their terminology ambiguous. A number of examples may be cited to illustrate the rate and type of progress.

One of the first steps in mapping African vegetation systematically and at a relatively large scale was taken in the Belgian Congo, where the Comité Spécial du Katanga not only produced topographic maps at 1:200,000 but, by superimposing a variety of green patterns, showed the vegetation as well.[5] The terms are physiognomic and show the vegetation in considerable detail, but they are also quite flexible. For instance, savannas are usually grasslands over which trees are scattered more or less openly. To show the differences in the density of the tree growth on the savannas, the map distinguishes under the heading of tree savanna (*savanne boisée*) three categories: poor, normal, and rich (i.e., in trees); the normal type is further broken down into three categories: tending toward poor, normal proper, and tending toward rich. This is an ingenious device to show rather fine differences without having to set up quantitative measurements which, in this case, would have been very time consuming without making much of a contribution. Granted that different field workers give their observations different interpretations which, indeed, may again differ from the interpretations of the

[5] Comité Spécial du Katanga, "La carte du Katanga, fueille Sakabinda," 1:200,000 (Bruxelles: Comité Spécial du Katanga, 1936).

reader of the map, such differences are not significant.

Although basically the approach on these maps is physiognomic, the map is enriched with floristic symbols which stand for such items as tree ferns, palms, or even *Borassus flabellifer*, which is a palm species. Bamboos are shown as a physiognomic type, as are *Papyrus* swamps. This method is, of course, related to Shantz's, but it is unlikely that there is any relation between the map of Africa and the Katanga map series, for the first sheet of the latter appeared almost simultaneously with the map by Shantz. By now, a considerable number of sheets have become available, and the series is being continued.

Whereas in the equatorial parts of Africa the rich flora and our ignorance of it made the physiognomic approach more or less inevitable, the far north of the continent presented very different conditions. This section had long been in close contact with Europe and had many types of vegetation which were well known to European students of vegetation, especially because many of these types occurred more or less modified on the Mediterranean shores of Europe as well. They were therefore Mediterranean types of vegetation rather than African. Marinelli's work in Cirenaica was still rather simple and mostly physiognomic.[6] In contrast, Maire gave us for the first time a relatively detailed map of Algeria and Tunisia, which is strongly floristic, and the names of species dominate the legend.[7] It should be noted that Maire shows species rather than genera, thus demonstrating an intimate knowledge of the vegetation which would have been impossible in tropical Africa at that time (1925). Even as floristic terms appear occasionally in the legends of physiognomic vegetation maps, so Maire employs "steppes," etc., on his map. Why he did this is not clear for there seems to have been no particular need for such exceptions to his rules. In any case, the rare physiognomic terms do not significantly affect the character of his map.

[6] O. Marinelli, "Schizzo topografico delle zone di vegetazione in Cirenaica," 1:1,500,000, in *La Cirenaica* (Milano, 1923).

[7] René Maire, "Carte phytogéographique: Algérie et Tunisie," 1:1,500,000, in Augustin Bernard and R. de Flotte de Roquevaire, *Atlas d'Algérie et de Tunisie* (Alger: Gouvernement Général de l'Algérie, 1925).

Perhaps the first map of any part of non-Mediterranean Africa where floristic terms appear in appreciable number is the vegetation map of southwest Madagascar by Basse.[8] Slightly more than half of the twenty-five legend items on this map are physiognomic; the remainder is floristic. Madagascar is, of course, an island and therefore offers certain advantages. Above all, it is a region with clearly established boundaries, the seashores, which eliminates the problem of having to integrate the vegetation with the vegetation of contiguous areas. Basse's map is relatively detailed and permits a considerable insight into the character of the vegetation. This map was particularly welcome because Shantz on his map of Africa had ignored Madagascar altogether. Actually, Perrier de la Bathie had published a vegetation map of the island as early as 1921, which could well have served Shantz as a good source, but he possibly may not have been acquainted with it.[9]

A revealing comparison also can be made of three vegetation maps of parts of French West Africa, all of which appeared more or less simultaneously. The map of the Ivory Coast has the largest scale and yet is the simplest, with the shortest legend (only three items: rainforest, deciduous forests, deciduous forests alternating with savannas).[10] Obviously, the Ivory Coast was at that time still very poorly known. On the map of Dahomey and Togo the number of legend items is eight, although the scale is appreciably smaller,[11] but Togo had been well explored by Engler whose information was available, and neighboring Dahomey is sufficiently like Togo to permit the integration of the vegetation of these two little countries. The map is physiognomic in character, like the map of the Ivory Coast, but has one floristic item (two species of *Isober-*

[8] Elaine Basse, "Répartition géographique des principaux groupements végétaux du sud-ouest de Madagascar," 1:550,000, *Annales des Sciences naturelles; botanique*, 10e série, Vol. XVI (Paris, 1934).

[9] Perrier de la Bathie, "Madagascar," 1:2,500,000, *Annales du Muséum Colonial de Marseille*, 3e série (Marseille, 1921).

[10] A. Aubréville, "Types de forêt, Côte d'Ivoire," 1:3,000,000, *La flore forestière de la Côte d'Ivoire* (Paris: Librairie Larose, 1936).

[11] A. Aubréville, "Dahomey et Togo," 1:5,000,000, *Bulletin du comité d'études historiques et scientifiques de l'Afrique Occidentale Française*, Vol. XX (Dakar, 1937).

linia). Interestingly enough, there are on the map (not in the legend!) two new items: *savannes boisées guinéennes* and *savannes boisées soudanaises*. Why are these two items not in the legend? Was Aubréville too uncertain about them and yet did not want to omit them? Physiognomically, the two savanna types are similar, but their floristic compositions are not: the first has southern affinities, whereas the other has northern ties, i.e., their species are more typical of broad vegetation belts in Upper Guinea and the Sudan, respectively. This is an attempt to introduce floral regions which are not based on vegetation types but on the geographical distribution of individual species. Floristic regionalism is highly developed in Europe, and the French students of vegetation have done much to extend this work into northern and western Africa. The third of three West African maps is purely floristic and at a much smaller scale.[12] This indicates, of course, the sharp decline in the number of species with the growing aridity, and hence the greater ease of characterizing a vegetation type by some dominant species. The three maps differ therefore fundamentally because of the varying amount of available information and the environmental conditions of the regions. To this may be added a much vaguer feature, the personal attitudes of the authors: the botanist Aubréville had perhaps a stronger geographical interest and saw vegetation as an integral part of the landscape.

Shortly after the appearance of the three maps of French West Afrcia, two maps were published, one of the Union of South Africa by Adamson,[13] and the other of Morocco by Emberger.[14] Both areas are considered Mediterranean in the character of their vegetation and climate; both also reach far into the adjacent arid lands; but the contrast in the maps is striking. Of Adamson's 17 divisions and subdivisions all but two of the latter are physiognomic; perhaps the tremendously rich and still incompletely explored flora forced Adamson to his categories although it had aroused the interest of a number of important botanists and a good deal of information on it had become available. Emberger, on the other hand, worked like Maire in a country bordering on the Mediterranean Sea. Indeed, his work is to a certain degree the western extension of Maire's work. Like Maire, Emberger proceeded on a floristic basis and includes a few non-floristic items. These, however, are not physiognomic but ecological, referring to types of environment rather than describing the vegetation. Furthermore, item 1, "Desert vegetation with Saharan flora," reveals, as in Aubréville's map of Dahomey and Togo, how firmly floristic regionalism had become established in the minds of the students of northwest African vegetation.

The first period, the prewar period, may here be closed with a vegetation map of the Belgian Congo by Lebrun.[15] Chronologically, Gossweiler's map of Angola also belongs here, but not in character. It is, therefore, better to shift it to the second or postwar period. Lebrun's map, although rather small, is a most fitting ending for the first period. This period was characterized by endeavors to describe the African vegetation at first physiognomically as the only way, then by refining the physiognomic descriptions with floristic data. Lebrun tries to be comprehensive and, wherever possible, to combine physiognomic, floristic, and ecological data, and while this is not feasible everywhere, he succeeds to a considerable degree. From a plant-geographical viewpoint this map is particularly interesting because it points out possibilities in analyzing vegetation types and fitting them into the landscape of which they are an integral part.

Beginning with Shantz's vegetation map of Africa and ending with World War II, the first act of the play was characterized by much activity, although only few of the participants displayed any original ideas. There was a complete lack of coordination, but in spite of the apparently unorganized procedure and the

[12] Y. Urvoy, "Sahara soudanais central: extension d'arbres et arbustes à peuplement dense," 1:15,000,000, *Annales de Géographie*, Vol. 46 (1937), p. 273.

[13] R. S. Adamson, "Distribution of vegetation types in southwestern Cape Province," 1:3,300,000, in *The Vegetation of South Africa* (London: British Empire Vegetation Committee, 1938).

[14] Louis Emberger, "Carte phytogéographique du Maroc," 1:1,500,000, in *Aperçu général sur la végétation du Maroc* (Zürich: Geobotanisches Forschungsinstitut Rübel, 1939).

[15] J. Lebrun, "Répartition de la forêt équatoriale et des formations végétales limitrophes dans le centre et le nord du Congo," 1:4,000,000, *Bulletin agricole du Congo belge*, Vol. XXVII, No. 2 (Bruxelles, 1936).

absence of cooperation, the steadily increasing number of vegetation maps had certain favorable results and implications. The chief result was, of course, that more vegetation on this large continent was actually mapped; the maps presented concrete information that could be checked in the field and could be interpreted and used for a variety of purposes. It follows that a great deal of knowledge about the vegetation of Africa was accumulating which, in turn, implied a deeper geographical, ecological, and botanical understanding of African plant life in general. The stage was now set for the second act.

THE SECOND PERIOD

The second act has no precise beginning. The postwar manner of vegetation mapping in Africa has a dual character. On the one hand, some maps differ little or not at all from their predecessors; it is as if the old and tried ways of mapping the vegetation of Africa were the only ways. Even among the most recent maps there are several that could easily have appeared 25 years earlier. On the other hand, there is a new and different feature which sets off the postwar period from the prewar period. It consists of a bold effort to apply to the African scene the highly developed ideas and techniques which had permitted European vegetation mappers to reach such unprecedented heights. This effort involves, above all, the areas which are (or were) French, Belgian, or Portuguese, comprising about half of Africa. The effect, however, is continent-wide.

Vegetation mapping in Europe evolved largely in particular schools of thought. The methods of these schools were carefully formulated and tried and often vigorously debated. Constant testing and critical reviewing perfected these mapping techniques to a very high degree until the more important of these methods are now widely employed. But Europe is a small continent, and its Pleistocene history resulted in an extremely simple flora when compared with that of other regions. Only its Mediterranean flora is somewhat richer. In addition, the climate of most of Europe is subject to only a minimum of fluctuations. This combination of a simple flora and a stable climate results in a vegetation that is poor in species and remarkably stable. To this must be added a most intimate knowledge of the European vegetation on which many scientists had trained their observations for centuries. Vast amounts of information had accumulated and were available when the modern methods of vegetation mapping evolved. Perhaps these are the ideal conditions under which to develop the study of vegetation and techniques to map it. Perhaps this also is the reason why European scientists outdistanced their colleagues on other continents, but when the European masters sent their students into Africa, conditions were quite different from what they were accustomed to. Anyone familiar with the European mapping methods and also with tropical vegetation could only watch the performance with fascination.

Throughout the postwar period vegetation mapping in Africa retained its dual character resulting in two types of vegetation maps, or what may here be called the old types and the new types. The old types persisted. Just because they offer little that is new, little need be said about them. If they are here mentioned at all and if examples are discussed, it is primarily to draw the reader's attention to interesting maps and to indicate that they do represent an important element among the modern vegetation maps of Africa.

To illustrate the evolution of African vegetation mapping, the vegetation maps of the Sudan might seem particularly appropriate. This country early aroused the curiosity of Europeans, at least in part because of the Nile which flows through this country for so much of its course. As Egypt shifted more and more from the Turkish into the British sphere of influence, the Upper Nile countries inevitably attracted increasing attention. As a result, nine different vegetation maps of the Sudan were published in the period 1896–1956, or a new vegetation map of the country every six years and eight months! A comparison of these maps is given in the following tabulation.[16]

[16] Emmanuel de Martonne, *op. cit.*; H. E. Hurst and P. Phillips, "The Nile Basin," 1:7,500,000, in *The Nile Basin*, Vol. 1, plate 29 (Cairo: Ministry of Public Works, 1927); T. F. Chipp, "Vegetation Belts of the Anglo-Egyptian Sudan," 1:17,000,000, *Geographical Journal*, Vol. LXXV (1930), p. 130; F. W. Andrews, "Vegetation Map of the Anglo-Egyptian Sudan," 1:25,000,000, in G. D. Tothill, ed., *Agriculture in the Sudan* (London, 1940); R. A. Hodgkin, "Vegetation

Number	Date	Number of legend items (subdivisions given separately)	Type
1	1896	6	Physiognomic
2	1927	8	Physiognomic
3	1930	7 + 3 subdivisions	Mostly physiognomic
4	1940	5	Physiognomic
5	1951	5	Physiognomic
6	1953	6	Physiognomic
7	1953	9	Physiognomic
8	1954	8 + 18 subdivisions	Ecological and physiognomic; subdivisions mostly floristic
9	1956	6	Mostly physiognomic

This series fails to demonstrate the evolution of vegetation mapping in Africa; from first to last the maps are all remarkably similar in almost every respect. There are variations, of course. For instance, on the map by Chipp (No. 3) the various vegetation types are arranged in an ecological sequence, and the larger scale and the more recent data of map No. 8 permit more floristic detail in the subdivisions, but map No. 8 is the only one which demonstrates that a good deal more is now known about the vegetation of the Sudan than when de Martonne published the first map of the series.

In American geographical circles Gillman's map of Tanganyika is well known.[17] It is interesting here because it represents the most detailed vegetation map of that country, and yet its vegetation types are purely physiognomic. Farther south, three vegetation maps of Mozambique or parts of it have been published.[18] The first one, covering the whole country, is physiognomic; the last one is floristic and has the largest scale. Between these two extremes the second map shows a happy combination of physiognomic, floristic, and ecological features. Farther inland, the authors of the map of Northern Rhodesia attempt to show the geographical distribution of vegetation types as related to soils.[19] This map has the added advantage of indicating a higher and a lower degree of reliability and by leaving all unmapped areas in white. The major types are physiognomic, and the subdivisions more (though not entirely) floristic. Finally, as a last example, the vegetation map of the Union of South Africa by Acocks deserves some comment.[20] With its 70 legend items it is very detailed and hence very valuable. Unfortunately, the use of a local terminology sharply reduces its value for readers overseas. Too many of the terms are cryptic to the point of creating real difficulties. For example, what sort of vegetation type is one to visualize from terms like 'Piet Retief sourveld," "False central lower Karoo," or "Lowveld sour bushveld"? Obviously, the map must be supported by supplementary literature to become intelligible. It would be an interesting and useful project to "translate" the legend of this map into a terminology that can be appreciated by people everywhere.

An important feature of the postwar period has been the introduction into the African scene of three advanced systems of studying and classifying vegetation. Largely restricted to Europe, they suddenly seemed to have reached a point of maturity which permitted their application to the tropics. The three systems are (1) the physiognomic (–ecological) system by Rübel; (2) the floristic (–ecological) system by Braun-Blanquet; and (3) the ecological system by Gaussen. Each of these systems has distinctive features which sharply separate it from the others, and there is little or no "overlapping" between them. They all claim universal applicability, at least in principle, and they all claim usefulness on maps of any scale. This statement, however, must be qualified by the observation that Rübel's

Map of the Sudan," 1:16,750,000, in *Sudan Geography* (New York: Longmans, Green, 1951); Sudan Survey Department, "Major Vegetation and Grazing Zones of the Anglo-Egyptian Sudan," 1:8,000,000 (Khartoum, 1953), and "Vegetation of the Sudan," 1:4,000,000 (Khartoum, 1954); L. Dudley Stamp, "Vegetation Belts of the Sudan," 1:17,000,000, in *Africa, a study in tropical development* (New York: Wiley & Sons, 1953); J. H. G. Lebon, "Anglo-Egyptian Sudan: Natural Vegetation," 1:30,000,000, *Geografiska Annaler*, Vol. XXXVIII (1956), p. 79.

[17] Clement Gillman, "Tanganyika Territory Vegetation Types," 1:2,000,000, *Geographical Review*, Vol. XXXIX (1949), p. 36.

[18] Ministerio das Colonias, "Carta fitogeográfica de Moçambique," 1:6,000,000, in *Atlas de Portugal ultramarino* (Lisboa, 1948); L. A. Granvaux-Barbosa, "Provincia de Zambézia, esboço da vegetação," 1:1,000,000, *Moçambique Documentario trimestral* (Lourenço Marques, 1952); Mario Myre Bento Ripado, "Esboço dos mais importantes agrapamentos herbaceos (Capinais)," 1:50,000, *Moçambique Documentario trimestral* (Lourenço Marques, 1953).

[19] C. G. Trapnell, "Vegetation-Soil Map of Northern Rhodesia," 1:1,000,000 (Lusaka: Department of Agriculture, Forestry Branch, 1948).

[20] J. P. H. Acocks, "Veld Types of South Africa," 1:1,500,000, *Botanical Survey of South Africa*, Memoir 28 (Pretoria, 1953).

system is used mainly at small scales, Braun-Blanquet's system on maps of very large scales, and Gaussen's system almost exclusively for the two scales of 1:200,000 and 1:1,000,000. Although different, they all claim to present the vegetation as an indicator of environmental conditions. This is done directly or by implication, but the important point is that they are directed toward a more profound appreciation of the African environment and, in turn, toward more rational land use.

Of the three systems, the one by Rübel has been used least. Perhaps this is due to the need (now great) for detailed studies. The vast expanses of Africa can now be mapped physiognomically and even with additional floristic information with relative ease as long as the map scale is small, but a much more detailed type of information is required to meet the growing pressure on the land. Perhaps it is for this reason that Rübel's system has not been applied over a large area. Rübel's terms are very good, based on sound thinking and comprehensive observation, but he organized his system in such a manner that every type of vegetation, no matter where in the world it occurs, must fit into one of only twenty-seven categories. This assures success only where there is no need for finer differentiations. Delevoy, on his map of Africa, describes the vegetation in physiognomic terms, sometimes supplementing these with regional names. Then, in parentheses he adds the equivalent terms of Rübel's classification. He follows this procedure also on a map of the Belgian Congo.[21]

Much more interesting is the map of Angola on which Gossweiler also uses Rübel's system.[22] The much larger scale permits considerable detail and the overall impression of the map is very favorable. Gossweiler reveals the advances in the exploration of Angolan vegetation by overprinting a large number of floristic symbols which permit many regional distinctions. We have then in Gossweiler's Angola map a demonstration of what Rübel's system can do in a tropical setting, and perhaps also of what it cannot do. From a geographical point of view, Rübel's system offers the advantage of establishing clearly defined physiognomic or ecological categories of vegetation in terms that can be used anywhere on the globe. This permits not only useful studies on the local scene but also intercontinental comparisons.

The Braun-Blanquet system of studying vegetation evolved mainly at Montpellier in southern France. It is floristic and recognizes a hierarchy of plant communities. These, properly explored and understood, can give detailed and comprehensive information on the environmental conditions of an area. The maps are very useful by themselves, but geographers and others will find that they can get the full benefit of these maps only when the maps and their supplementary texts are used together. Furthermore, Braun-Blanquet's system can be successfully employed in quite unlike types of environment. The French are particularly fortunate in the fact that they can study the vegetation on both the north and the south shore of the Mediterranean Sea, and so extend their accumulated knowledge and experience from Europe to Africa without having to adjust to any fundamental differences in the character of the vegetation. Once a bridgehead is firmly established on the north coast of Africa, the study of the vegetation can be extended step by step into and beyond the Sahara. Some very interesting work recently has been published demonstrating that the Braun-Blanquet system can certainly be used successfully in the Mediterranean part of Africa.[23] It may be argued, however, that vegetation maps à la Braun-Blanquet of the Mediterranean part of Africa do not represent an unusual achievement, since the area is in character Mediterranean rather than African. Surely its vegetation is more closely related to that of southern France than to that of Guinea. Can a system which works well in France work equally well in equatorial regions?

The answer was given by the Belgians who were trained in the use of Braun-Blanquet's

[21] G. Delevoy, "Carte de la répartition des formations végétales en Afrique," 1:62,000,000, and "Carte de la répartition des formations végétales au Congo," 1:18,750,000, in Maurice Robert, *Le Congo physique* (Liège, 1946).

[22] John Gossweiler, "Carta fitogeográfica de Angola, 1:2,000,000, in John Gossweiler and F. A. Mendonça, *Carta fitogeográfica de Angola* (Lisboa: Edição do Govêrno Geral de Angola, 1939).

[23] Gilbert Long, "Carte des groupements végétaux: Henchir-Gamouda," 1:12,500, *Annales du Service botanique et agronomique de Tunisie* (Paris, 1954).

system in northwestern Europe and who then employed it right on the equator. The contrast could hardly be much greater. The Belgians have published numerous vegetation maps of their Congo region. The majority, of course, did not use the Braun-Blanquet classification, and of these, Liben's map of Yangambi and Devred's map of Kwango are excellent examples.[24] They are physiognomic in character, with floristic and ecological information given where feasible, but the feasibility of this method had been demonstrated before, and the more crucial question was to what extent associations and other floristic communities in Braun-Blanquet's terms could be established meaningfully in an equatorial vegetation. Of course, it was useless to even experiment with a floristic system until a great deal was known about the flora, but after World War II the time seemed ripe. Good examples of Congo vegetation maps using the Braun-Blanquet method are the maps of Mvuazi and Nioka.[25] The scale is always quite large. Alliances, associations, and subassociations are basic units in the hierarchy of the classification, and all are shown. Where there was doubt in the mind of the mapper, he speaks more broadly of plant communities (*groupements*) rather than employing one of the strictly defined categories, leaving it to later researchers to determine the exact rank that such plant communities hold in the hierarchy. Doubts have been expressed that some of these associations can be verified, but even if the mappers were carried away by their enthusiasm, it does now seem possible to map the vegetation of the humid tropics accurately and in great detail wherever the flora is sufficiently well known. It is a matter of getting to know the plants and no longer a lack of proper mapping methods.

The last of the great European systems to be discussed here is the one developed by Gaussen of Toulouse. Every American geographer interested in vegetation mapping is well acquainted with the superb map of Perpignan and the other sheets of the same series.[26] Gaussen presents the vegetation physiognomically and floristically, including both natural and cultural communities, together with the environment to which these vegetation types are inextricably bound. Gaussen's preferred scales of 1:200,000 and 1:1,000,000 are large enough to show the vegetation in detail and small enough to present areas of generous proportions. Of all vegetation maps prepared by botanists, Gaussen's maps are the geographer's choice; together with their inset maps, legend, and marginal notes they reveal the nature of the region as comprehensively as can possibly be expected.

In Africa his maps are done just like the various sheets of France so that anybody acquainted with the system has no problem in recognizing the familiar features. The best examples are his maps of Béni–Abbès, Bosquet–Mostaganem, Oran, and Rabat–Casablanca.[27] His sheet of Thiès (Senegal) differs from the others.[28] Actually, Gaussen supplied only the ideas for the use of colors and their patterns, but the vegetation categories were established by his collaborators. The "*étages*" and "*séries*" are conspicuous by their absence; instead, we find such items as "*Secteur soudano–sahelien occidental*" or "*Secteur sénégambien paralittoral.*" This is the floristic regionalism which is interesting in itself but helps the geographer relatively little. Of particular interest is Gaussen's map of Tunis–Sfax because here Gaussen employs the scale of 1:1,000,000.[29] For many geographers, such a broad view of the vegetation is often more advantageous than the highly focussed maps

[24] L. Liben, "Yangambi (Yambaw)," 1:50,000, and R. Devred, "Kwango," 1:1,000,000 (Bruxelles: Institut National pour l'Étude Agronomique du Congo belge, 1955).

[25] R. Devred, "Mvuazi (Bas Congo)," 1:50,000, and L. Liben, "Nioka (Ituri)," 1:50,000 (Bruxelles: Institut National pour l'Étude Agronomique du Congo belge, 1954).

[26] Henri Gaussen, "Carte de la végétation de la France, feuille Perpignan," 1:200,000 (Toulouse: Service de la carte de la végétation de la France, 1948).

[27] P. Guinet, "Carte de la végétation de l'Algérie, feuille Béni-Abbes," 1:200,000; S. Santa *et al.*, "Carte de la végétation de l'Algérie, feuille Bosquet-Mostaganem," 1:200,000; A. Theron and J. Vindt, "Carte de la végétation du Maroc, feuille Rabat-Casablanca," 1:200,000 (Toulouse: Service de la carte de la végétation de la France, 1958).

[28] Henri Gaussen, Guy Roberty, and Jean Trochain, "Carte de la végétation de l'Afrique Occidentale Française, feuille Thiès," 1:200,000 (Toulouse: Service de la carte de la végétation de la France, 1950).

[29] Henri Gaussen and A. Vernet, "Carte internationale du tapis végétal, feuille Tunis-Sfax," 1:1,000,000 (Toulouse: Service de la carte de la végétation de la France, 1958).

of very large scales and very small areas. If, in the past, the sheets of the 1:200,000 series overawed any geographers, there is now in the Tunis–Sfax map a fine example available which may more readily stimulate efforts among geographers to emulate the master of Toulouse.

The last example in this long list of African vegetation maps is also one of the most recent.[30] We started with Shantz's map of the continent (excluding Madagascar) at 1:10,000,000 and now we return to a map of Africa (excluding the area north of the Tropic of Cancer) also at 1:10,000,000. As the United Nations Educational, Scientific, and Cultural Organization (UNESCO) was instrumental in publishing this map, it will be referred to here as the UNESCO map. Over one-third of a century passed between the publication dates of the two maps, tremendous strides have been made, the vegetation is now much better known and understood than at any other time, and it requires now maps of at least 1:1,000,000 before any white spots will appear. How is this long and exciting history reflected in the UNESCO map? How does it compare with the Shantz map?

The great progress in mapping the African vegetation consists above all in more vegetation being mapped accurately than ever before and in applying new techniques which permit a sharp focus on details, but the UNESCO map is at the same scale as Shantz's map. Thus, it may justifiably be asked to what extent any of the progress in vegetation mapping can be expressed at such a small scale. Obviously, the ideas behind the detailed work shown on some large-scale maps of the Congo region simply do not apply at 1:10,000,000. This scale must necessarily result in broad generalizations, and if new information can be expressed in such generalizations, then, indeed, this is also a record of progress.

A comparison of the Shantz map with the UNESCO map reveals the following features. Both maps have the same scale and on both maps the vegetation is presented physiognomically. If Shantz employs floristic terms such as *Acacia* or mangrove, then such floristic terms must imply physiognomic information. On the UNESCO map, however, floristic terms do not serve the same purpose, but rather make floristic distinctions within physiognomic types. For instance, the term "woodlands and savannas" is used for both legend items No. 17 and No. 18; they are physiognomically analogous. But the first (northern) type is rich in *Isoberlinia doka* and *I. dalzielii*, whereas in the second (southern) type *Brachystegia* and *Julbernardia* dominate. The Shantz map has twenty legend items as compared with thirty-five on the UNESCO map. This greater detail is surely the result of incorporating knowledge that became available after Shantz published his map. A few items are actually or so nearly the same that they may be assumed to be identical. This includes mangroves, desert, montane grasslands or mountain grass, moist forest at low and medium altitudes or tropical rainforest, and others. It will be noticed that these parallels apply mainly to vegetation types of rather extreme environmental conditions. Therefore, if the UNESCO map shows a greater differentiation, this applies above all to the various kinds of savannas, grasslands, and "steppes." Several times, the vegetation types on the UNESCO map are distinguished on a regional basis: "Madagascar type," "western Uganda type," etc. The Shantz terms are brief, descriptive, and self-explanatory, whereas the legend items on the UNESCO map are not only more numerous but often longer. Shantz supplements his map with a small book on the vegetation; the UNESCO map is accompanied by "Explanatory Notes" concerning the nature of the vegetation types, which sometimes are essential, as in the case of such obscure terms as "Itigi type." Even less cryptic items, like "Ethiopian type," are not really too helpful until the Explanatory Notes come to the rescue. These notes are good, but it should have been possible to condense them somewhat and then print them directly on the map, i.e., on an expanded margin, somewhat as Gaussen does it. This would have eliminated the Explanatory Notes as a separate pamphlet and greatly strengthened the map.

Vegetation mapping has made enormous strides in Africa. The need for vegetation maps is being recognized, and so they are made. This both requires and leads to more elaborate studies of vegetation. In the modern inves-

[30] R. W. J. Keay *et al.*, "Vegetation Map of Africa south of the Tropic of Cancer," 1:10,000,000 (London: Oxford University Press, 1959).

tigations of African vegetation, the vegetation maps are therefore both cause and effect. Gradually, the vegetation maps cover the continent, and the scale increases as time goes on. So far, only tiny spots in the vastness of the African landscape have been mapped at really large scales, but the areas mapped at 1:4,000,000 or larger cover nearly half the continent.

The way to the solution of important problems is being paved. Problems in geographical research in which vegetation maps can function as important tools include the recognition of natural regions and of land-use potentials. To these may be added problems in climatology, including micro-climatology, and problems in the geography of soils and landforms, drainage and irrigation, and many others. Those interested in plant geography or the geographical distribution of vegetation in Africa will be richly rewarded by the use of the newly available vegetation maps. The problem of the origin of the savannas, for instance, is closer to its solution now that good vegetation maps are being published. As the various savanna types are recognized and their more detailed distribution pattern becomes known, it is more feasible to link them to both the static and the dynamic features of their environment. In this manner new light can be shed on their true nature and their origin.

More comprehensive and more detailed vegetation mapping permits better comparative studies. These may involve comparisons of different savanna types within Africa, as well as comparisons of African savannas with those in South America, southern Asia, and Australia. The benefits from comparative studies are twofold: characteristics of the landscape and its vegetation may be revealed, and the experiences gained in Africa due to the more advanced state of vegetation mapping there can serve as guideposts for similar research in all analogous vegetation types throughout the tropics.

A. W. KÜCHLER
University of Kansas

ANNALS MAP SUPPLEMENT NUMBER ONE

CYPRUS—A Landform Study

NORMAN J. W. THROWER
Department of Geography
University of California, Los Angeles

The production costs of this map were contributed by the following firms: Denoyer Geppert Company, Follett Publishing Company, C. S. Hammond & Company, A. J. Nystrom & Co., Rand McNally & Company, and Scott Foresman & Co. The Map Editor wishes to express his appreciation to these firms for their generosity.

Unfolded copies of this map may be obtained from the Central Office of the Association of American Geographers, 1785 Massachusetts Ave., N.W., Washington 6, D.C. Price, 65c for the first copy, 35c each additional copy, postpaid.

RICHARD EDES HARRISON
Map Editor